

Daily report

19-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries have definitely lost leadership in absolute number of cases worldwide. Currently, the **USA, Russia and Brazil are clearly the leaders**. USA has been the country with highest number of cases since March 27, surpassing Italy at that time. Russia overtook Spain on May 13, which was the European leader that day. Brazil has overtaken the UK today, according to ECDC data.

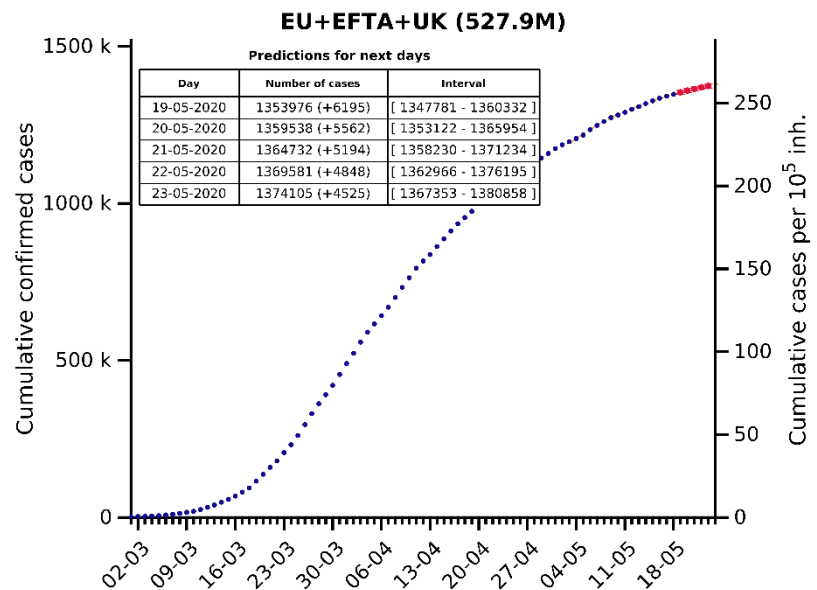
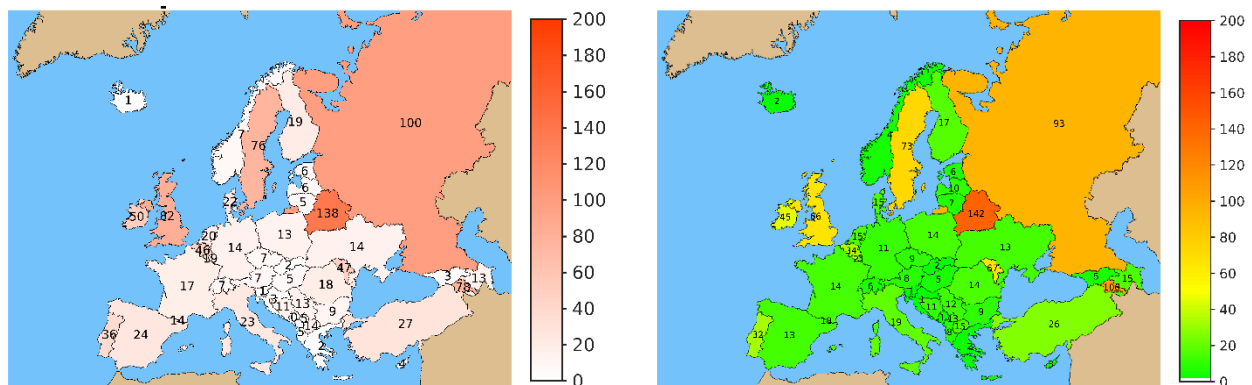
On the other hand, while **European countries are significantly slowing down their growth**, the USA, Russia and Brazil are still growing dramatically, without any symptom of slowdown. The epicenter of the epidemic has definitely shifted. It started in China, then jumped to Europe, and now it is clearly growing in the Americas.

Today's analysis and those of the following days are focused on discussing the role of *test and tracing* and *mobility* on the deconfinement process. They have been elaborated together with researchers from the Barcelona Supercomputing Center.

Trends for specific countries

Globally, EU+EFTA+UK countries are gradually moving to the level of 5,000 daily new cases. **UK** seems stabilizing at $\rho_7 = 0.8$, thus plenty entering a decreasing stage. **Sweden** reports a low number of new cases today, which drags the ρ_7 below 1. Both countries show a gradual decrease in EPG.

The map in the left shows current **A₁₄**. The map in the right shows current **EPG**.



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. Last column (EPG_{EST}) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). EPG_{REP} is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
United Kingdom	246,406	370.9	34,796	52.4	55,822	84.0	0.80	68	982
Spain	231,606	499.7	27,709	59.8	11,362	24.5	0.56	14	162
Italy	225,886	380.1	32,007	53.9	13,948	23.5	0.80	19	267
Germany	175,210	213.9	8,007	9.8	11,350	13.9	0.80	11	52
France	142,903	220.8	28,239	43.6	11,040	17.1	0.82	14	266
Belgium	55,559	489.2	9,080	79.9	5,292	46.6	0.74	34	574
Netherlands	44,141	259.9	5,694	33.5	3,371	19.8	0.75	15	192
Switzerland	30,514	356.1	1,602	18.7	616	7.2	0.81	6	32
Sweden	30,377	308.8	3,698	37.6	7,656	77.8	0.96	75	998
Portugal	29,209	281.6	1,231	11.9	3,685	35.5	0.90	32	140
Ireland	24,200	512.1	1,547	32.7	2,478	52.4	0.89	47	299
Poland	18,885	49.4	936	2.4	4,879	12.8	1.09	14	81
Romania	17,036	86.1	1,107	5.6	3,524	17.8	0.79	14	102
Austria	16,179	185.7	629	7.2	610	7.0	1.13	8	31
Denmark	10,968	192.0	548	9.6	1,298	22.7	0.66	15	75
Czech Republic	8,586	80.9	297	2.8	767	7.2	1.28	9	33
Norway	8,249	153.7	233	4.3	402	7.5	0.55	4	12
Finland	6,380	115.9	300	5.5	1,053	19.1	0.88	17	85
Luxembourg	3,947	685.2	107	18.6	119	20.7	1.12	23	58
Hungary	3,556	36.5	467	4.8	491	5.0	1.07	5	76
Greece	2,836	25.4	165	1.5	204	1.8	1.21	2	14
Bulgaria	2,259	31.7	112	1.6	607	8.5	1.04	9	50
Croatia	2,228	52.9	95	2.3	127	3.0	0.46	1	NA
Iceland	1,802	494.7	10	2.7	3	0.8	0.29	0	NA
Estonia	1,784	136.0	64	4.9	81	6.2	1.06	7	NA
Lithuania	1,547	53.2	59	2.0	128	4.4	1.40	6	NA
Slovakia	1,495	27.5	28	0.5	82	1.5	1.38	2	NA
Slovenia	1,466	70.5	104	5.0	27	1.3	0.53	1	5
Latvia	1,009	51.2	19	1.0	113	5.7	1.60	9	NA
Cyprus	917	78.4	17	1.5	43	3.7	0.78	3	NA
Malta	558	130.1	6	1.4	78	18.2	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	0	0.0	NA	NA	NA

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	Best	Best	Best	0.0	0

⁽¹⁾ ρ_3 is the average of 7 consecutive ρ , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_7 .

Highlights for countries with highest number of reported cases

- ✓ Spain is revising historical series of other regions with minor variations, including a one-day peak of 2,700 cases in Catalunya (so, ρ_7 not reliable).
- ✓ Spain, Italy, Germany and France are clearly below the level of 1,000 daily cases. UK could situate below 3,000 the next days.
- ✓ UK, Italy, Germany and France have a ρ_7 of 0.8.

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	85	11	16
Germany	79	12	17
France	78	10	20
Spain	77	8	12
United Kingdom	74	10	12
Belgium	73	11	14
Netherlands	73	11	20
Sweden	73	10	28
Norway	73	2	7
Switzerland	73	8	11
Austria	71	10	14
Denmark	70	4	30
Czech Republic	67	11	NA
Finland	67	12	46
Greece	67	18	NA
Iceland	67	5	15
Portugal	66	9	15
Slovenia	66	6	NA
Estonia	65	5	30
Ireland	65	8	18
Poland	65	17	NA
Romania	65	15	NA
Luxembourg	62	6	7
Slovakia	61	24	NA
Bulgaria	60	30	NA
Croatia	60	12	NA
Hungary	59	20	NA
Latvia	59	12	NA

Analysis: Assessment on the relevance of testing and mobility in the next stage of the epidemic.

The slow process of reopening the economy, with the consequent increase in mobility and contacts, requires multiple measures to check that it is done carefully so that new outbreaks are small and can be controlled. In this sense, the ability to contact and trace becomes crucial. The ability to test and trace depends on three interacting factors:

- 1) Setting up the laboratory structure which allows the performance of a large number of tests at the local medical centers. In this sense, we have established the **DTL** of an area (Daily Testing Level) as the key number defined as the **number of tests a region or country can do per day per 100.000 people**. We have explained in previous reports that countries showing $DTL \approx 50-100$ indicate that they have a reliable structure to do tests.
- 2) The ability to **find all people in close contact with a positive case and put them in quarantine** requires a minimum structure of people making calls and requesting isolation. These people should be tested immediately upon the appearance of symptoms. It is thus important to have an index indicating the level of tracing requested.
- 3) Mobility and interactions with people who are not familiar to the infected people transform the problem of contacting with close ties to a much more challenging process of **tracking sustained contacts with strangers in public gatherings**. These long interactions with people without kinship happen in classes/training, long commutes in trains/buses/planes, bars and restaurant interiors, socio-cultural gathering (theatre, cinema, sports...).

In the present stage of the epidemics when **mass gatherings are not allowed**, we state that **these three factors can be taken into account by two indexes**, one relating with the **ability to do tests** compared with the number of cases and the other on **mobility** to obtain a surrogate for an upper bound on the number of contacts a possible positive case can interact with.

We focus today on the ability to test the infectious population and its close contacts, and we will devote subsequent reports to mobility. Regarding the former, both the DTL and the number of estimated active cases becomes crucial. We defend that a proper picture of the challenges a particular country faces to do contact and trace of close relatives is given by the index $DTL/A_{14,EST}$, where $A_{14,EST}$ is the number of estimated active cases per 10^5 inhabitants. This index defines the **number of tests divided by the number of infected people per 10^5 inhabitants that can propagate the disease**. It defines the tracing capability as a ratio, so we call it **TCR** (Tracing Capability Ratio). A low value makes contact tracing impossible while a large value makes it perfectly feasible. A large value allows for contact tracing at the local level as long as there is a minimum of staff who can call the kinship contacts of those tested positive.

The number of estimated active cases can be obtained from the diagnostic rate (DR) of each country with a methodology that we confirmed in the report yesterday. Here we provide a table for key countries. While there are huge differences between states within the United States and regions within each country, this table gives a very good global picture of the situation in those countries which have been more affected by the epidemics.

Country	Population (M)	Daily tests ⁽¹⁾	DTL	DR (%)	A _{14,REP}	A _{14,EST}	TCF=DTL/A _{14,EST}
USA	328	320,000	100	15	88	590	0.17
Italy	60	60,000	100	7	26	370	0.27
Spain	47	40,000	85	8	23	290	0.29
France	67	24,000	35	5	18	360	0.10
Germany	83	67,000	80	20	15	75	1.01
UK	66.5	65,000	100	7	87	1240	0.08
Denmark	6	15,000	250	20	26	130	1.92
South Korea	51.5	15,000	30	40	5	12	2.5
Israel	9	15,000	165	60	4	7	23.6

⁽¹⁾ This is not the last value, but the maximum number achieved.

We can divide the countries in three clear groups. First, those with TCF>1 are already doing test and tracing with no major difficulties. **Clearly TCF>1 indicates that the system is ready. TCF<0.25 is an index too low**, making test and tracing very difficult or impossible. The fact that this is aggregated data for countries means that some areas within countries can start the process but, in general, UK, USA or France are not ready to test and trace successfully.

Finally, those with TCF>0.25 but TCF<1 are countries which can try the implementation of the test and trace scheme in those areas of the country less affected. Let us focus here on the meaning of TCF as a number and why TCF≈0.25-0.5 marks the effective threshold to start test and tracing. Given that people spend roughly 4 days without symptoms, it means that you have at least four days of testing available to cover new cases. Therefore, TCF at 1/4= 0.25 is a good rule of thumb number that fits those countries who are able to start the process

With values of **TCF around 0.5, a country/region is able to test all the new cases appearing every day and all the close contacts who may develop symptoms (50-60%) and still have some spare capacity to test and trace old cases.** Countries with **TCF around 0.25 can probably track new cases but it is difficult for them to process the backlog of 14 days of active cases.**

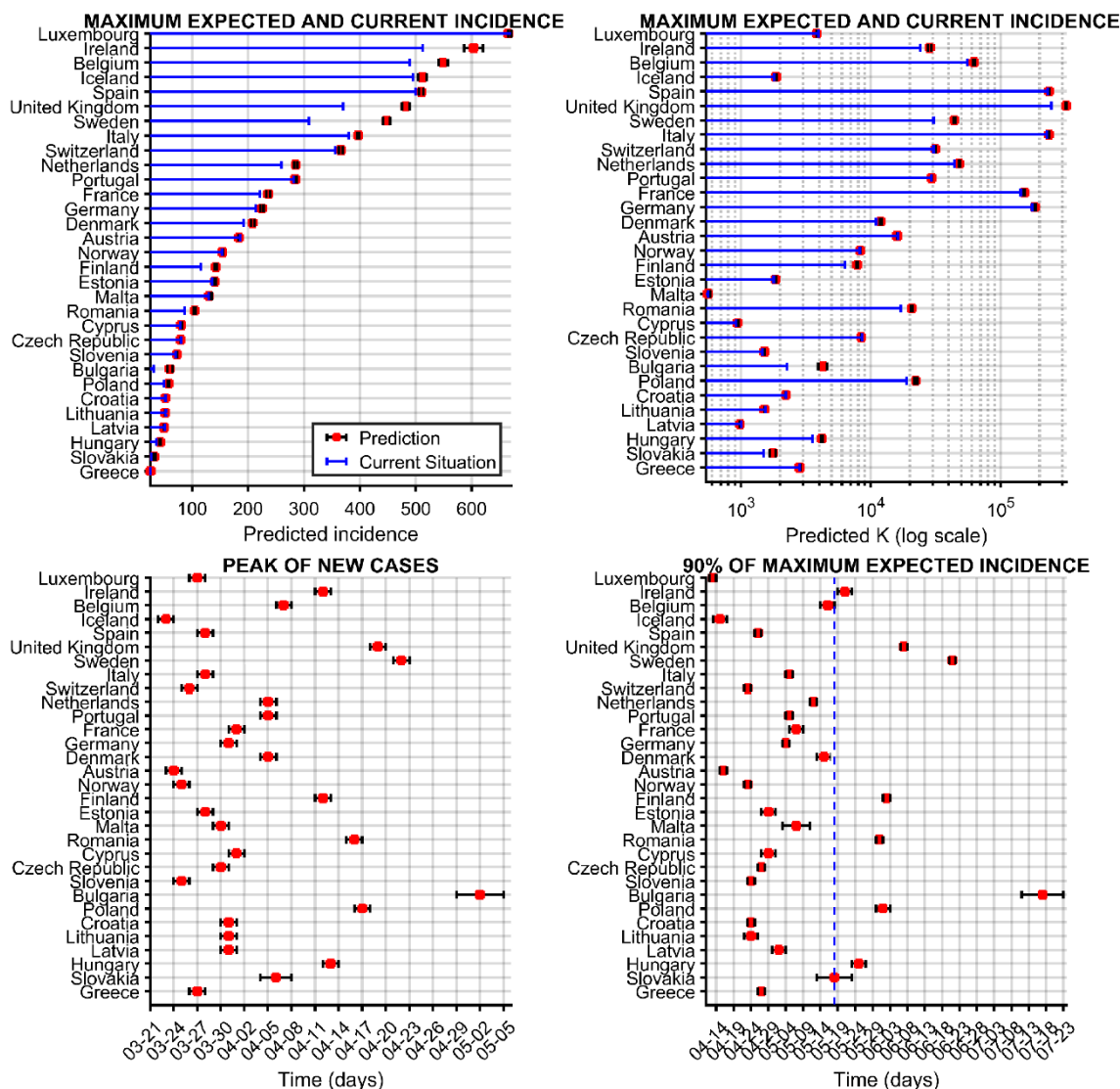
TCF at these values also indicate the presence of regions or areas where test and tracing can be done within each country. For example, in the case of Spain, using DTL=85 and a typical diagnosis rate of 8% we can compute the TCF for nine regions which represent the typical variability we find in Spain.

It is clear from this table that Spain, and probably Italy too, can try to test and trace new cases in areas with low active cases but will have more serious problems in areas with higher incidence like Castilla y León, Madrid and Catalunya given the large backlog of cases. Similarly, areas like Asturias or Murcia are perfectly capable to test and trace all infected.

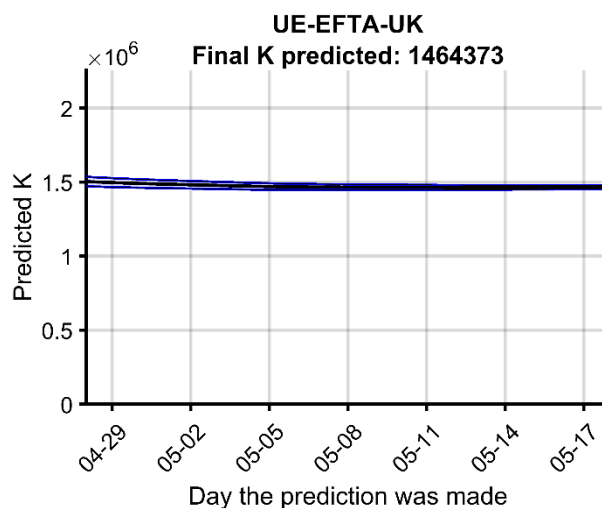
Region	A _{14,REP}	A _{14,EST}	TCF=DTL/A _{14,EST}
Castilla y Leon	49	610	0.14
Madrid	38	475	0.18
Catalunya	38	475	0.18
Euskadi	22	275	0.30
Aragón	15	190	0.45
Galicia	13	160	0.53
C. Valenciana	9	110	0.77
Islas Baleares	7	90	0.95
Asturias	5	60	1.42
Murcia	4	50	1.70

Long-term predictions

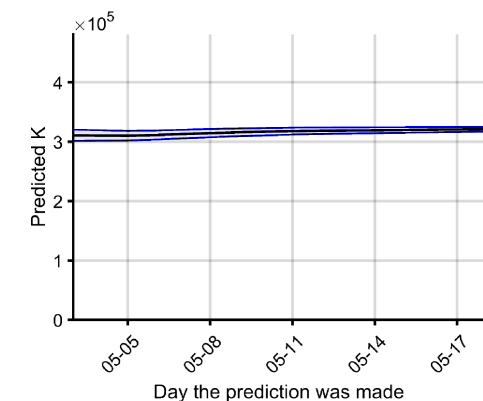
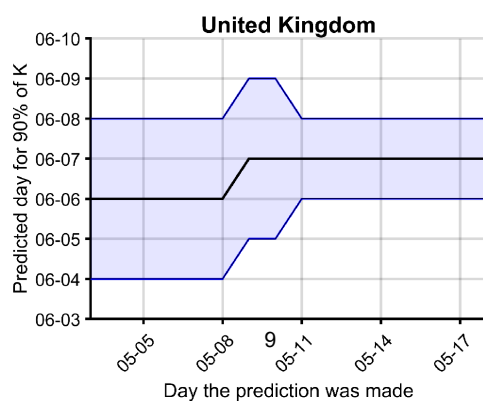
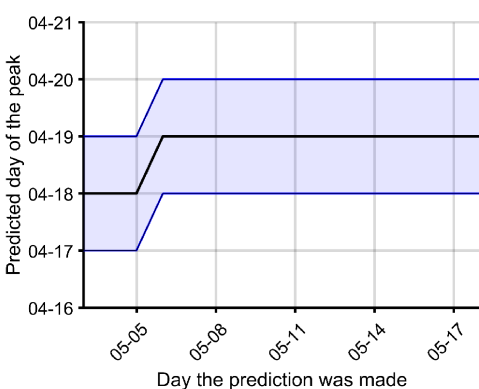
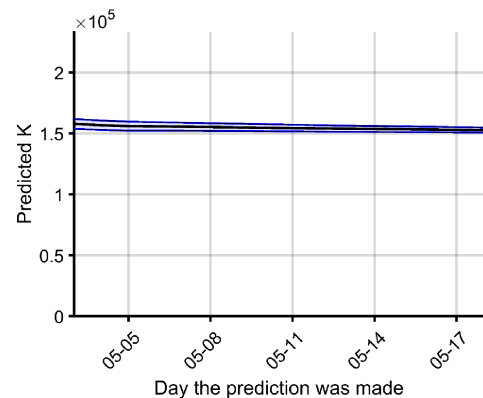
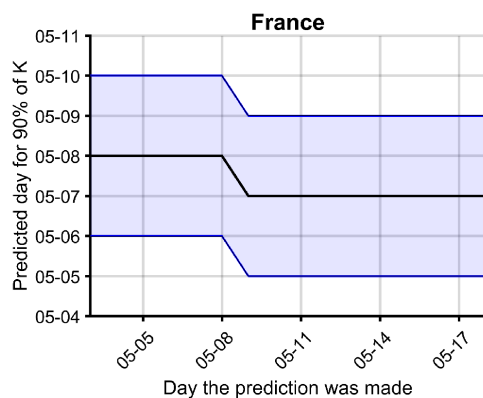
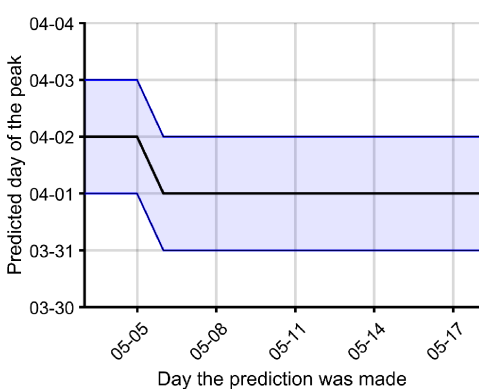
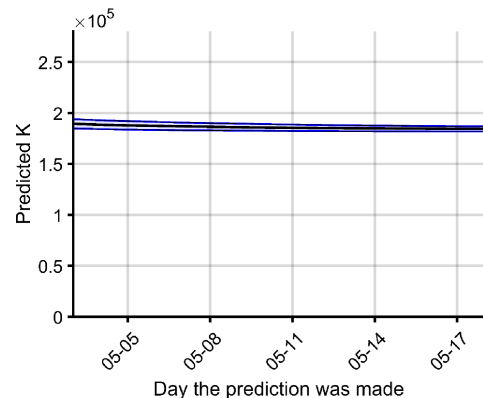
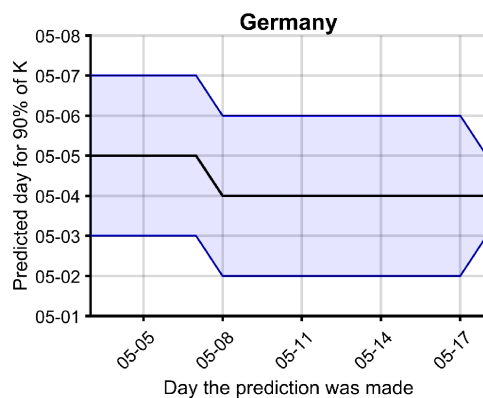
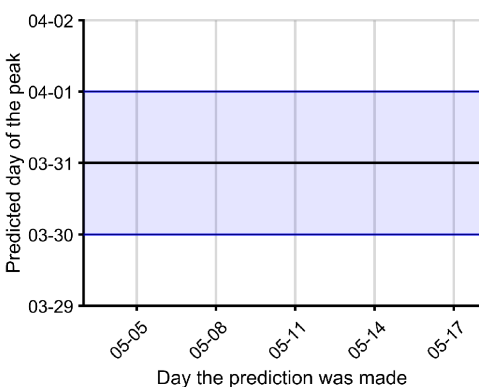
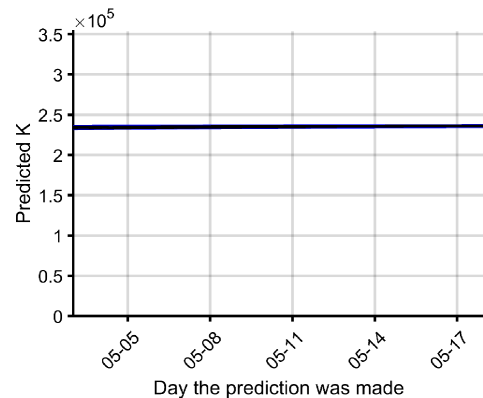
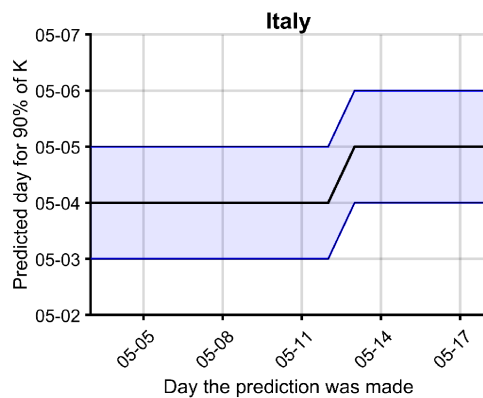
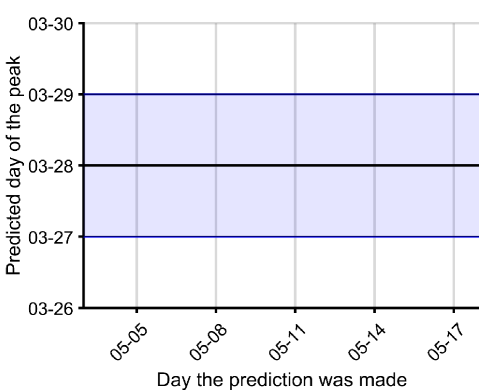
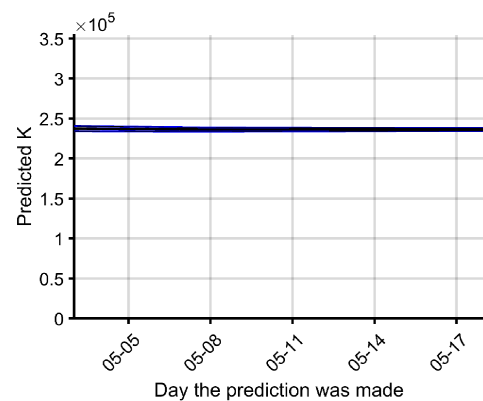
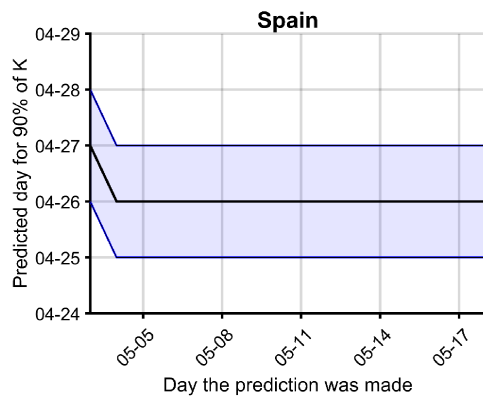
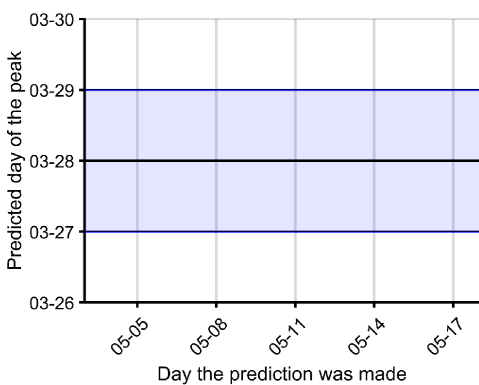
Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



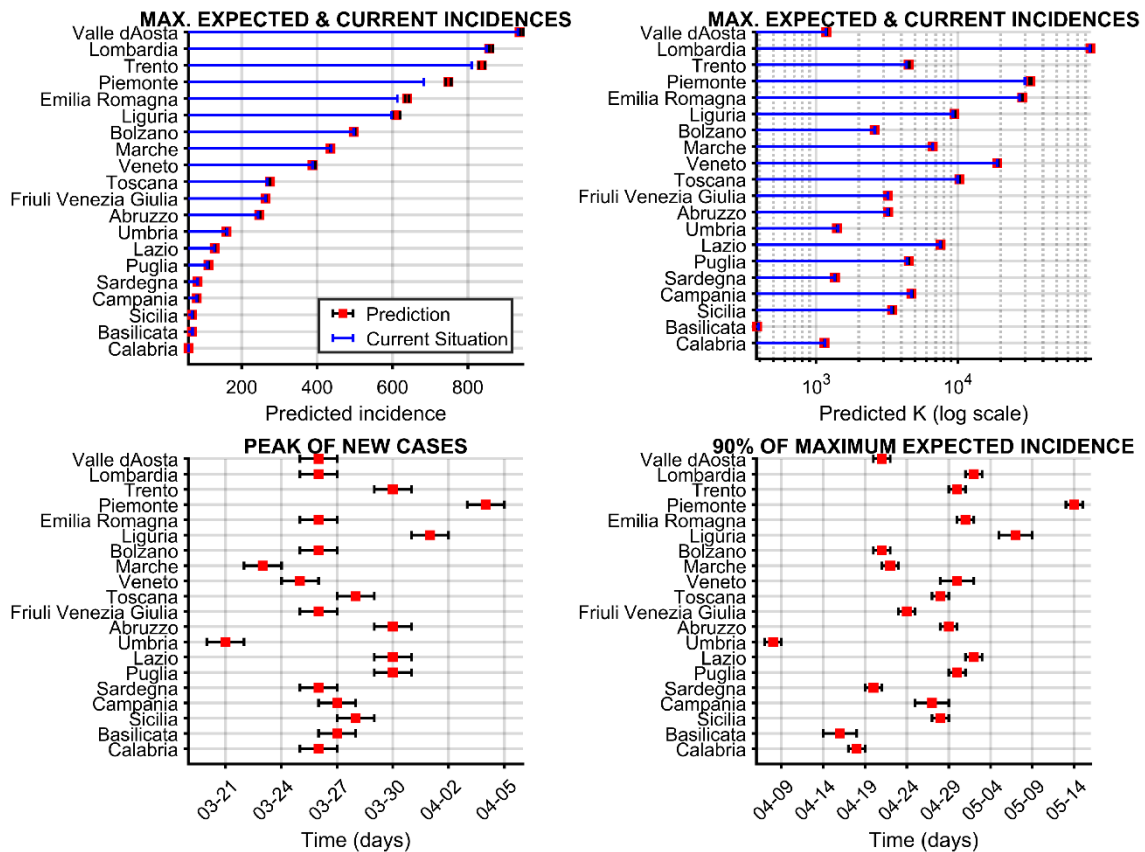
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



2020-05-18



Italian regions



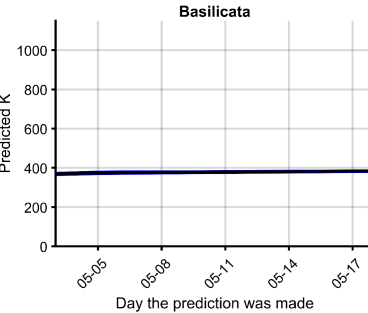
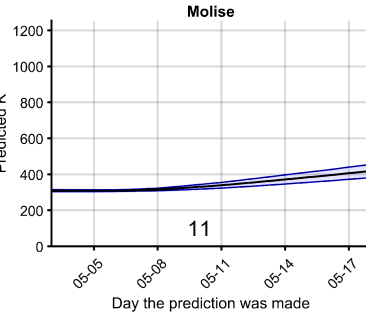
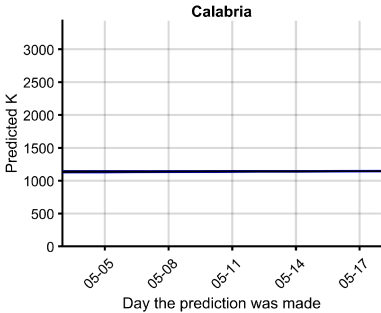
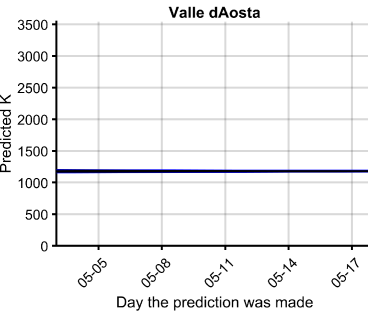
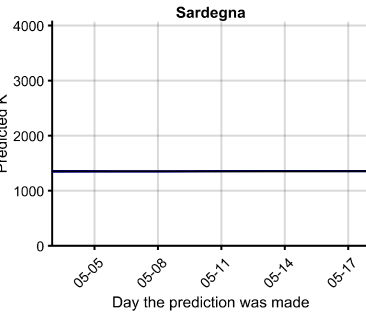
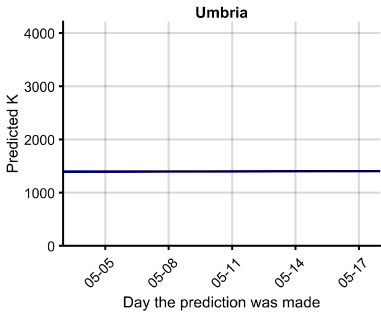
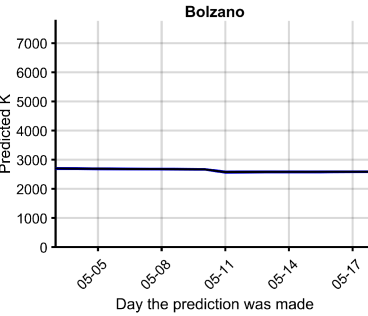
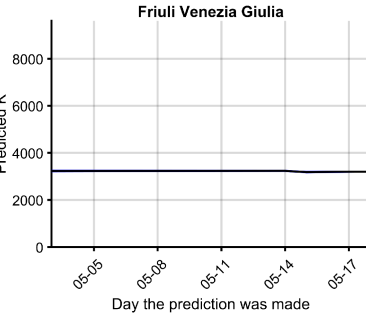
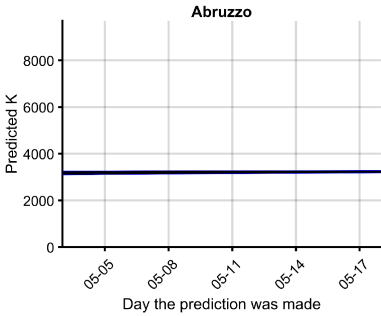
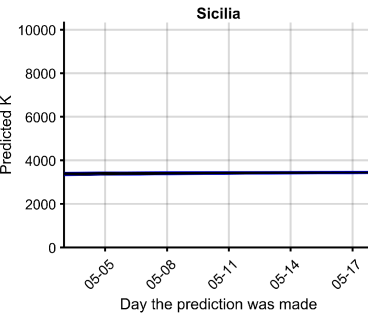
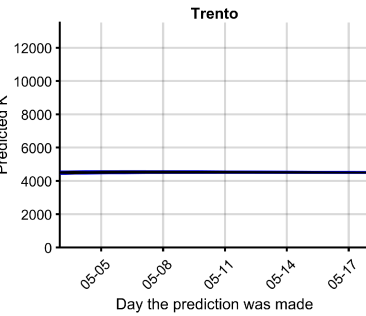
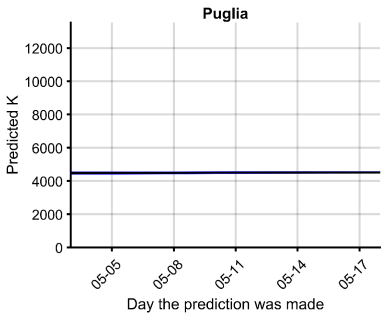
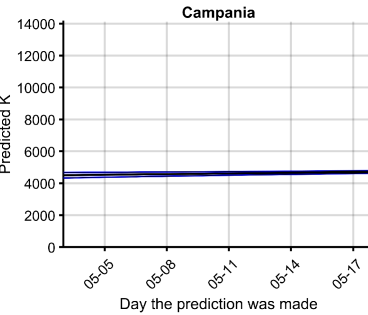
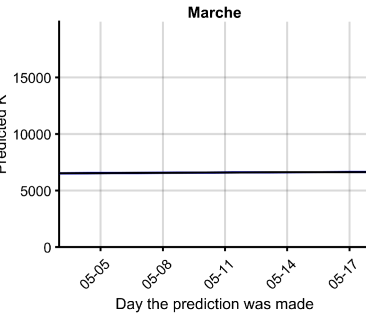
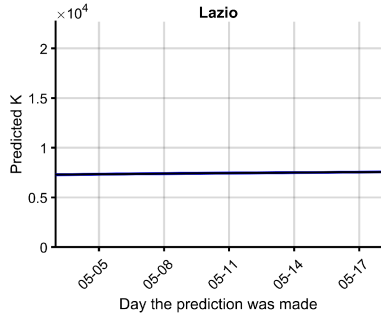
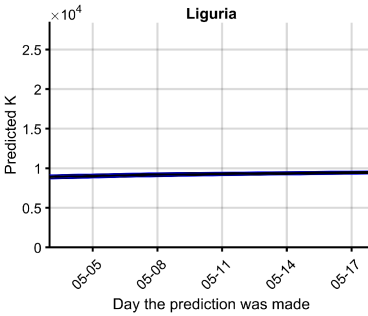
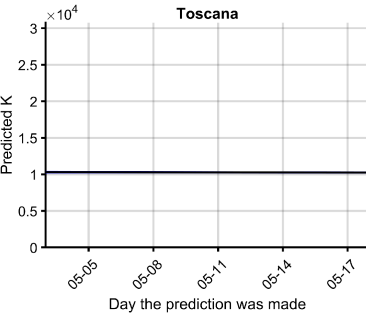
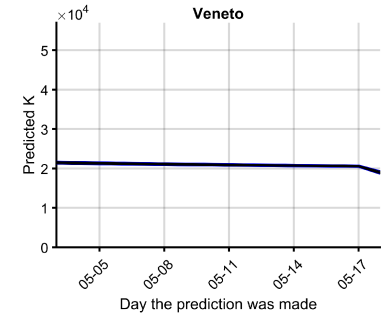
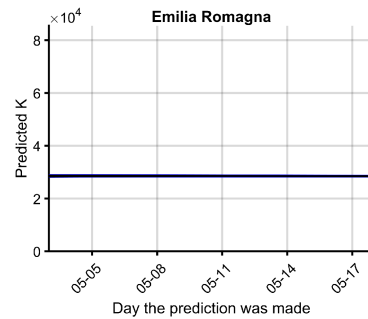
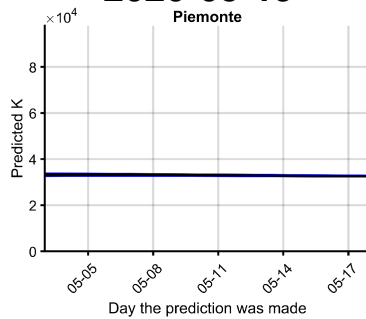
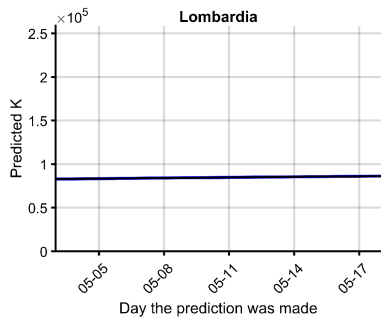
Situation and trends in Italian and Spanish regions

Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10^5 inh.	Cumulative deaths	Mortality / 10^5 inh.	Active cases (last 14 days)	14-day attack rate / 10^5 inh	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Lombardia	85.481	851,2	15.597	155,3	6.876	68,5	0,77	53	969
Piemonte	29.727	682,4	3.679	84,5	1.953	44,8	0,79	35	443
Emilia Romagna	27.314	612,5	3.997	89,6	1.039	23,3	0,69	16	238
Veneto	18.997	387,2	1.820	37,1	595	12,1	0,68	8	78
Toscana	9.968	267,3	992	26,6	337	9,0	1,05	9	97
Liguria	9.257	597,0	1.376	88,7	782	50,4	1,09	55	826
Lazio	7.505	127,7	640	10,9	591	10,1	1,18	12	105
Marche	6.675	437,6	986	64,6	283	18,6	0,77	14	214
Campania	4.707	81,1	399	6,9	189	3,3	0,97	3	27
Puglia	4.396	109,1	473	11,7	226	5,6	0,47	3	28
Trento	4.358	406,4	455	42,4	97	9,0	1,49	13	272
Sicilia	3.403	68,1	268	5,4	136	2,7	0,78	2	17
Friuli Venezia Giulia	3.203	263,6	320	26,3	118	9,7	1,00	10	98
Abruzzo	3.197	243,8	389	29,7	172	13,1	1,18	16	191
Bolzano	2.587	2.407,9	291	270,9	45	41,9	0,57	24	55
Umbria	1.427	161,8	74	8,4	27	3,1	0,89	3	NA
Sardegna	1.354	82,6	126	7,7	36	2,2	0,59	1	12
Valle d'Aosta	1.175	935,5	143	113,8	32	25,5	0,95	24	286
Calabria	1.153	59,2	95	4,9	34	1,7	0,95	2	NA
Molise	422	138,1	22	7,2	121	39,6	0,49	19	NA
Basilicata	393	69,8	27	4,8	-3	-0,5	0,45	0	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	200	2000
Best	Best	Best	Best	Best	Best	Best	0,0	0	0

2020-05-19



Spain*

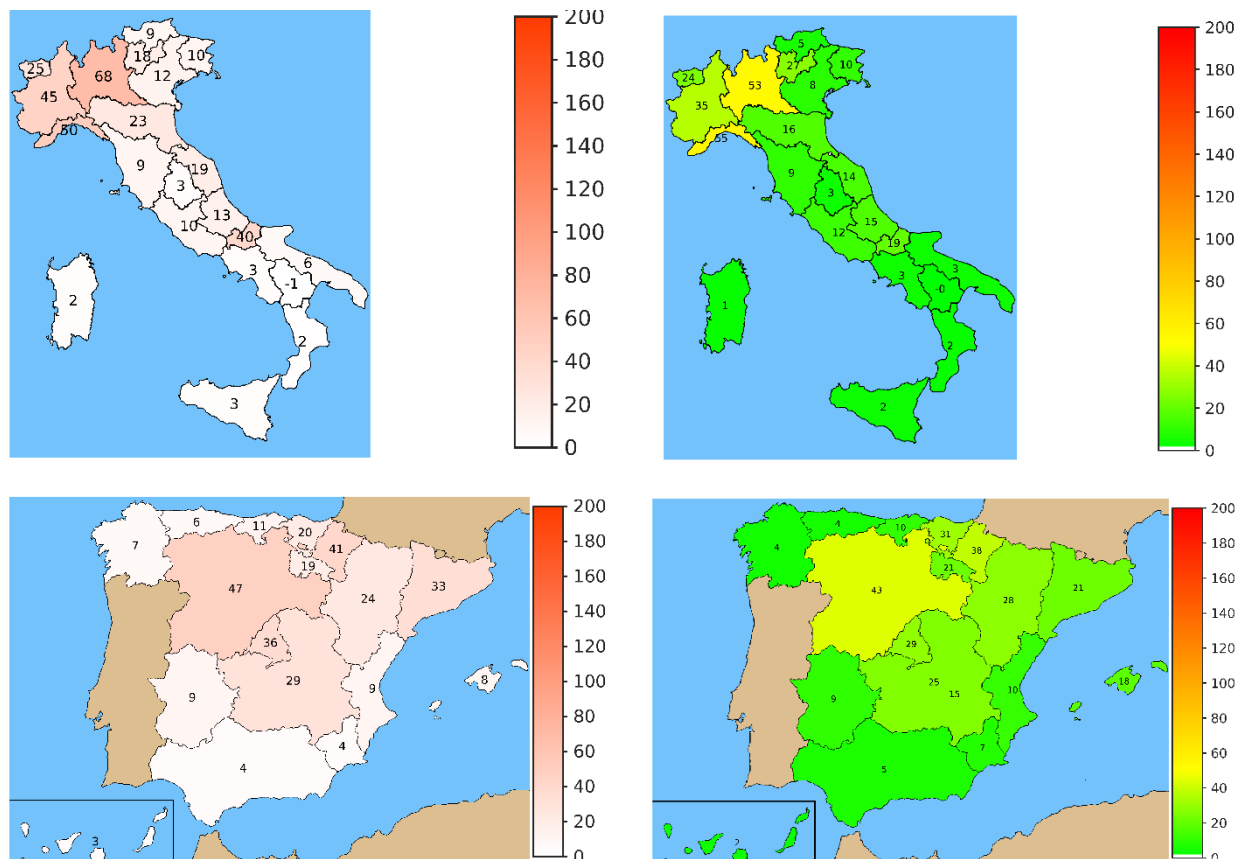
Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulated deaths	Mortality rate /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Madrid	66.643	1.003,6	8.894	133,9	2.408	36,3	0,79	29	384
Catalunya	53.329	704,9	5.981	79,1	2.558	33,8	0,64	22	249
Castilla y Leon	18.549	770,3	1.960	81,4	1.120	46,5	0,93	43	464
Castilla-La Mancha	16.677	819,3	2.900	142,5	597	29,3	0,86	25	438
Euskadi	13.409	615,6	1.470	67,5	444	20,4	1,54	31	339
Andalucia	12.471	148,0	1.358	16,1	304	3,6	1,50	5	59
Comunitat Valenciana	10.962	220,4	1.370	27,5	462	9,3	1,12	10	132
Galicia	9.058	335,4	607	22,5	177	6,6	0,54	4	24
Aragon	5.520	417,9	843	63,8	313	23,7	1,16	27	432
Navarra	5.202	800,3	503	77,4	266	40,9	0,9	38	372
La Rioja	4.027	1.284,2	352	112,3	60	19,1	1,12	21	180
Extremadura	2.953	277,2	504	47,3	101	9,5	0,98	9	155
Asturias	2.373	232,1	303	29,6	58	5,7	0,76	4	53
Canarias	2.294	103,9	155	7,0	63	2,9	0,85	2	17
Cantabria	2.273	390,8	208	35,8	66	11,3	0,87	10	89
Baleares	2.005	168,8	219	18,4	97	8,2	2,1	17	192
Murcia	1.558	104,7	145	9,7	62	4,2	1,69	7	68
Melilla	121	142,8	2	2,4	2	2,4	NA	NA	NA
Ceuta	117	137,9	4	4,7	16	18,9	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	200	2000
Best	Best	Best	Best	Best	Best	Best	0,0	0	0

* This report has been elaborated without consolidated dataserries from ISCii, so the results are provisional (data published by Health Ministry).

⁽¹⁾ ρ_7 is the average of 7 consecutive ρ , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_7 .

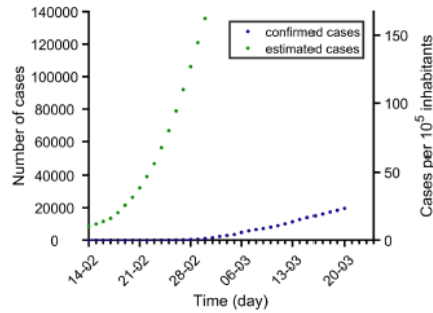
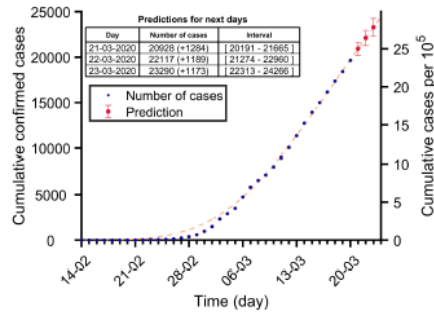
The **maps** in the left show current **A₁₄**. The maps in the right show current **EPG**.



Legend: Countries' reports details

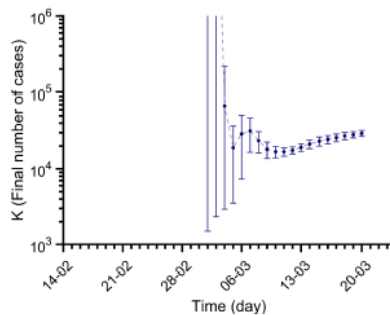
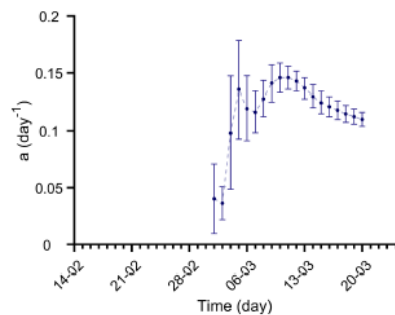
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)



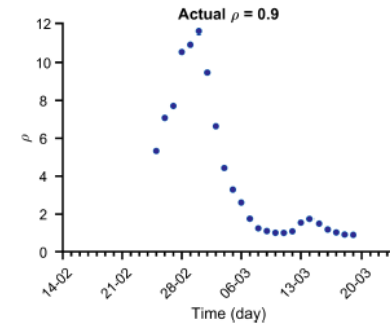
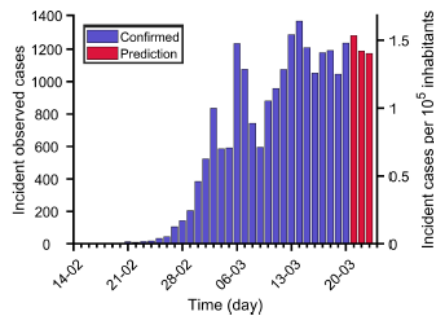
Estimated
cases using
death rate (see
Methods)

Fitted a value
using points
prior to each
date



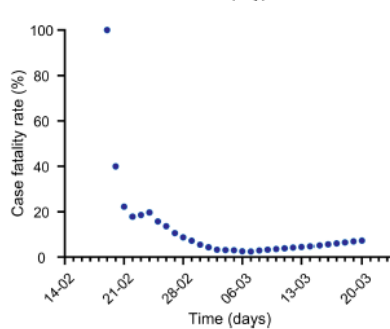
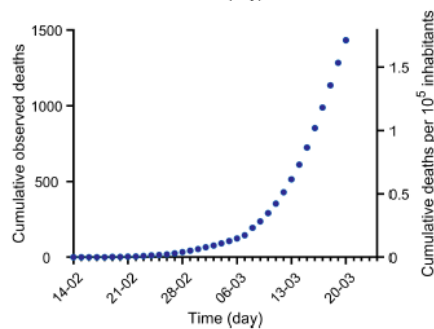
Fitted K value
using points
prior to each
date

Reported
and
predicted
new cases



Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)

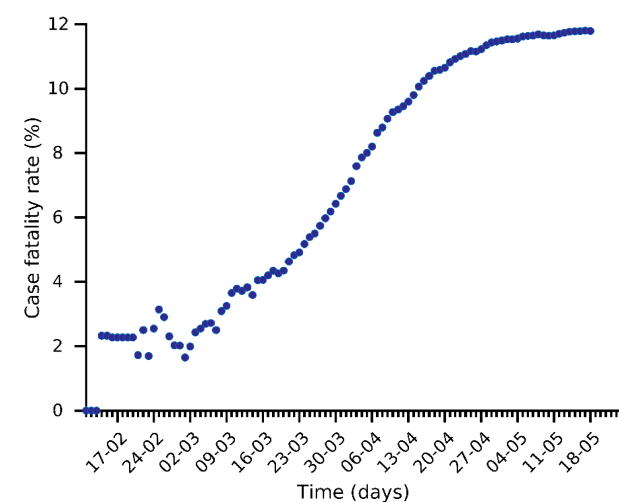
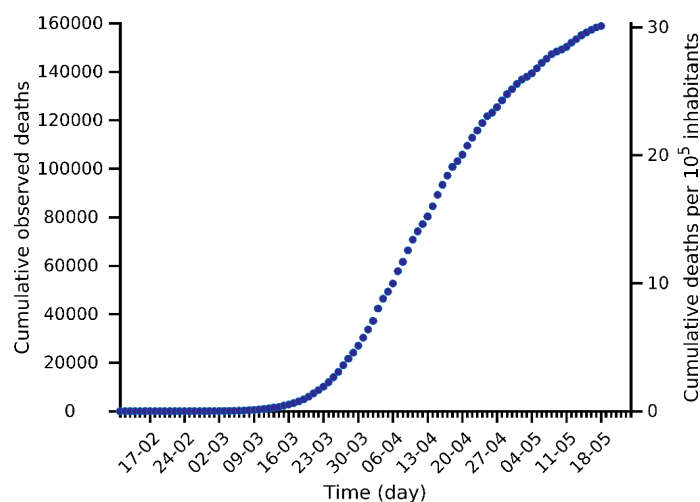
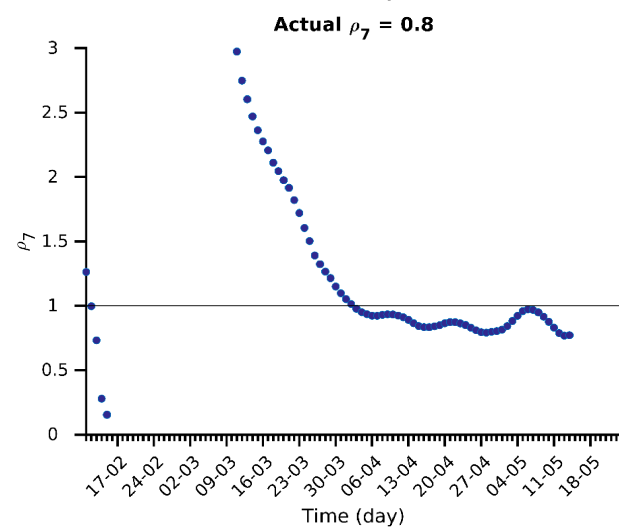
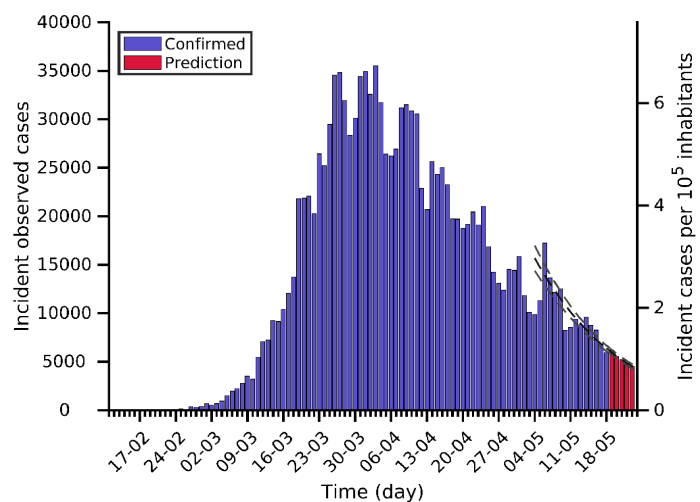
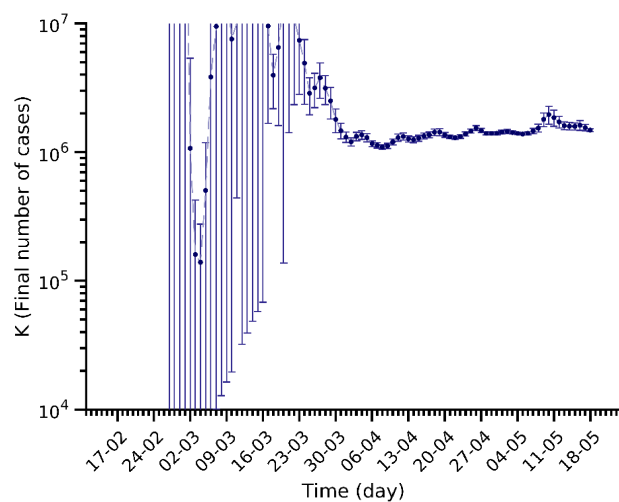
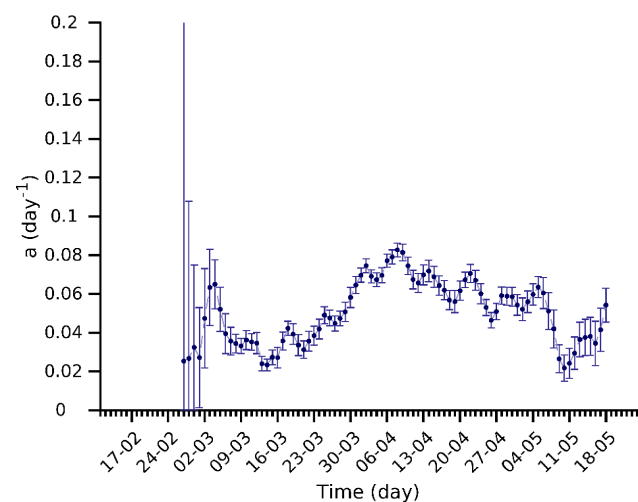
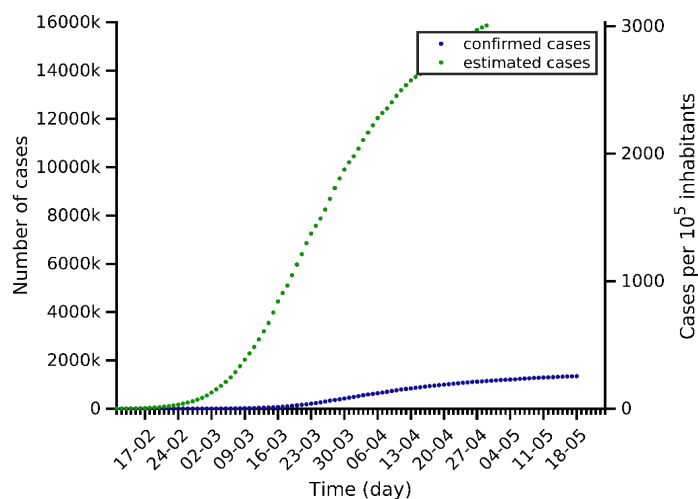
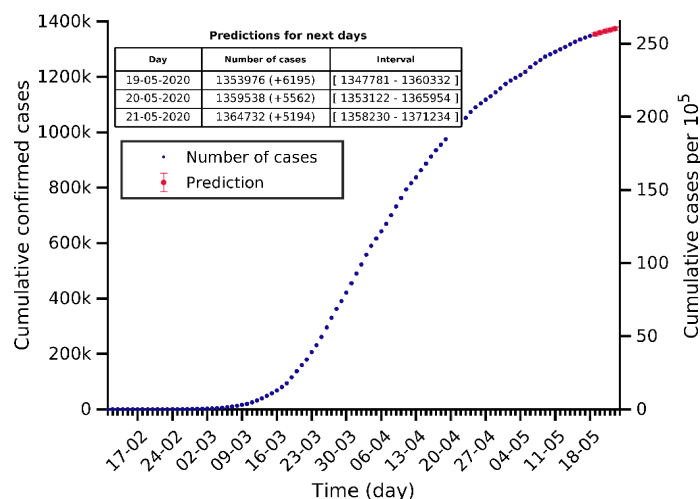
Reported
deaths



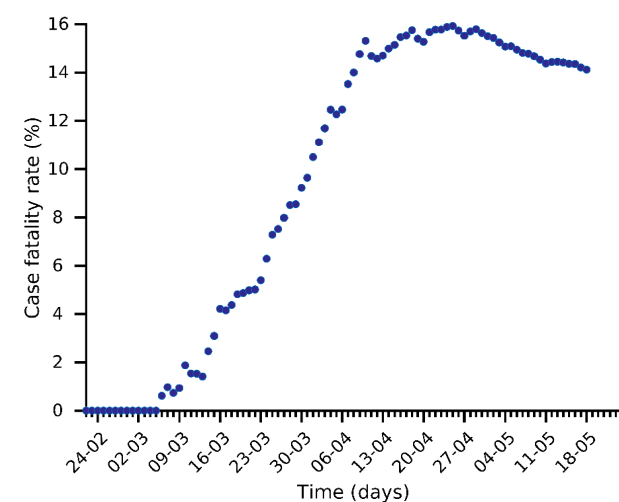
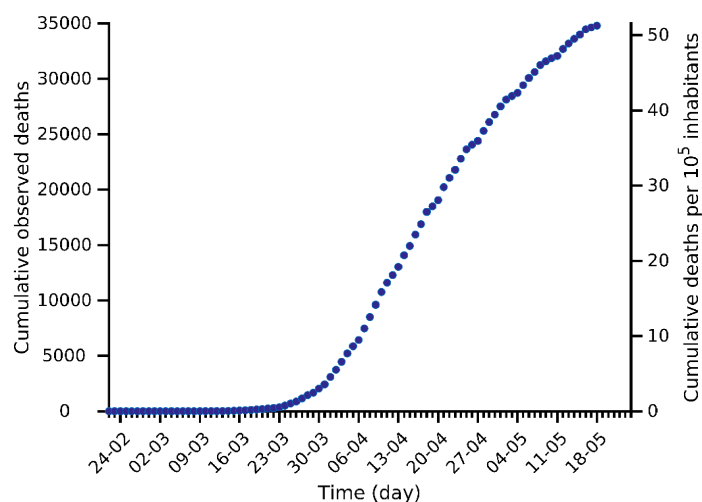
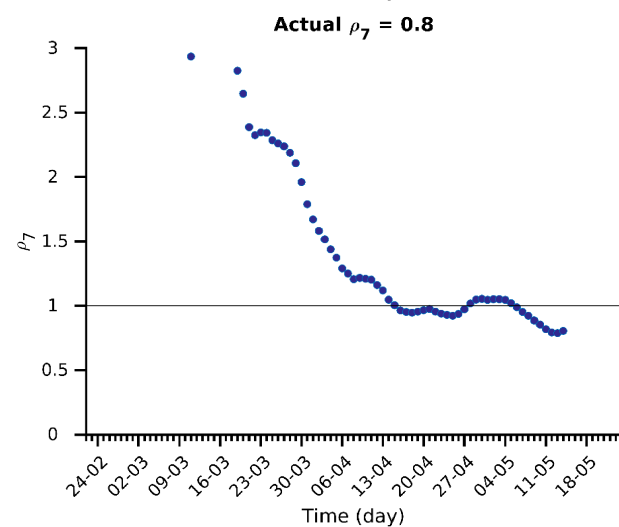
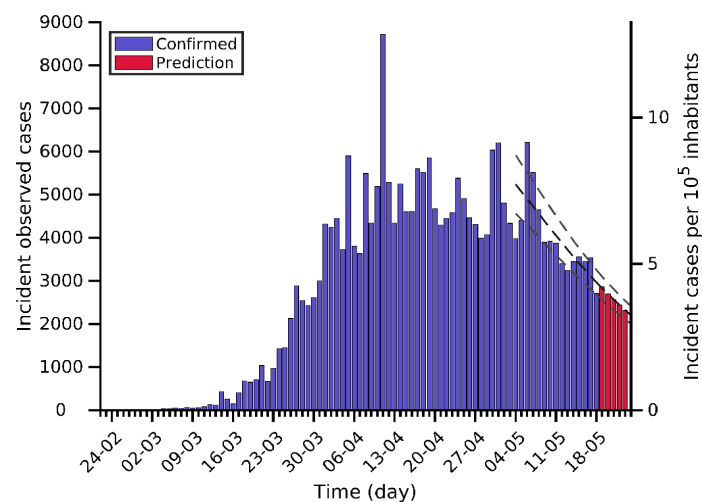
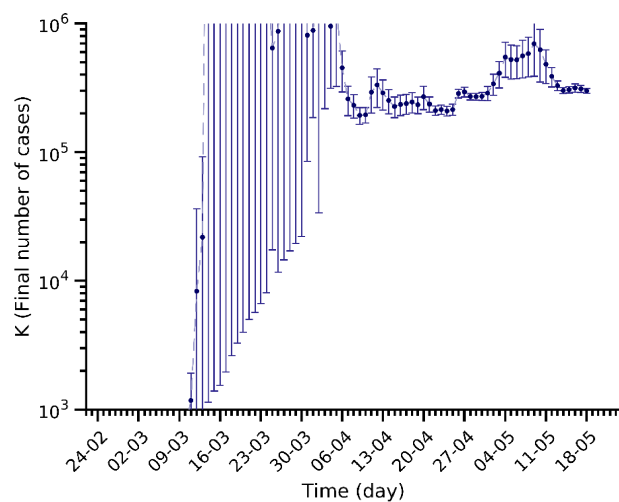
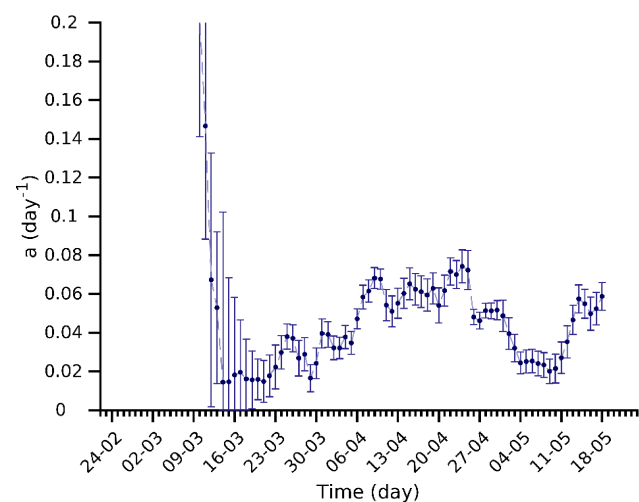
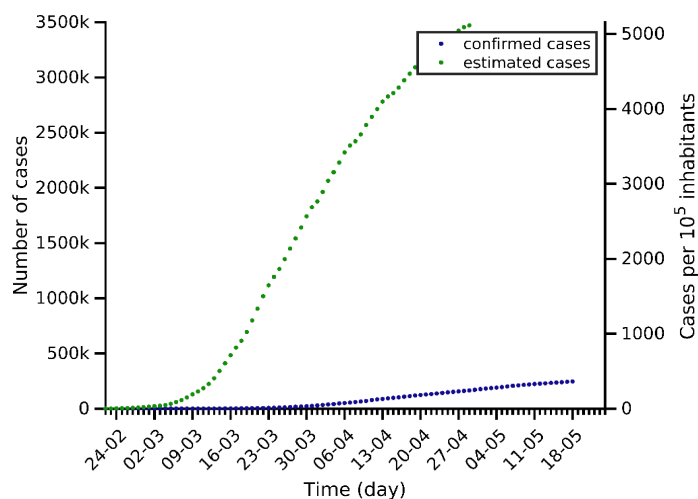
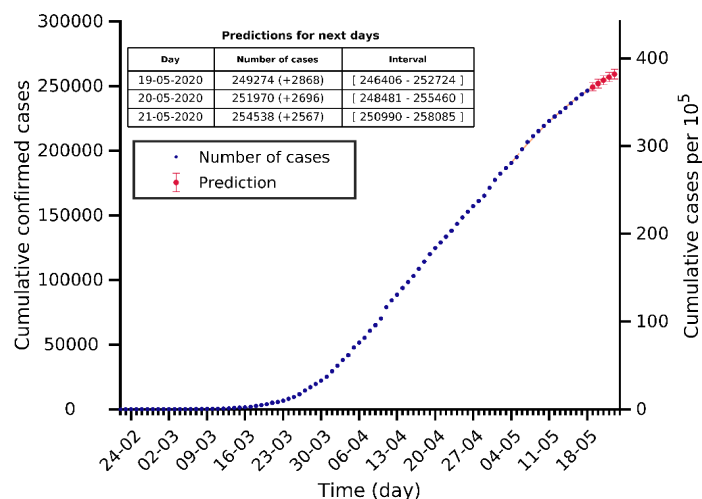
Deaths /
cumulated
reported cases

(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

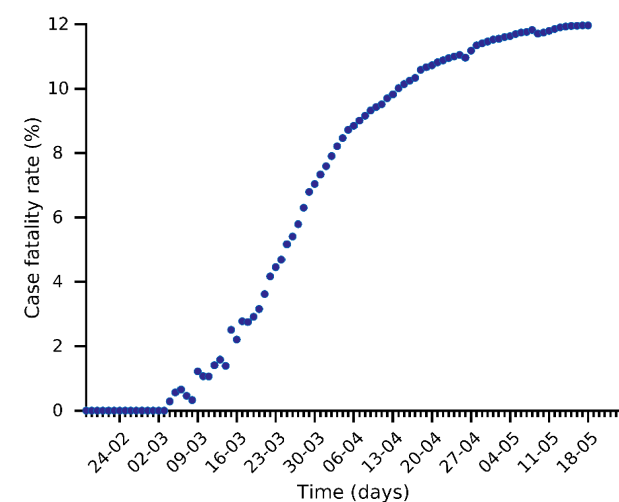
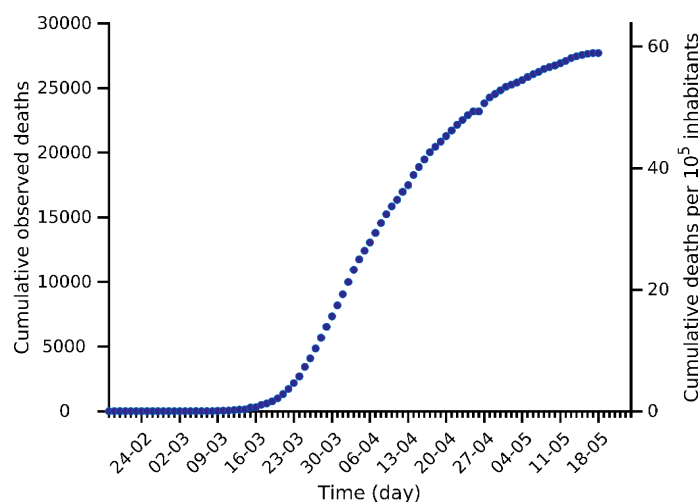
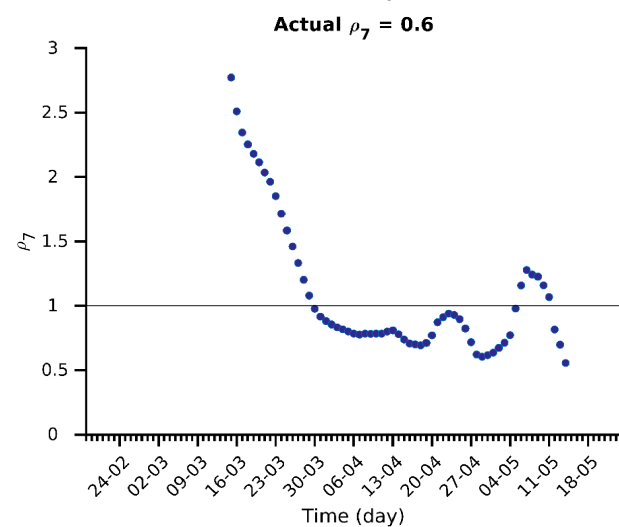
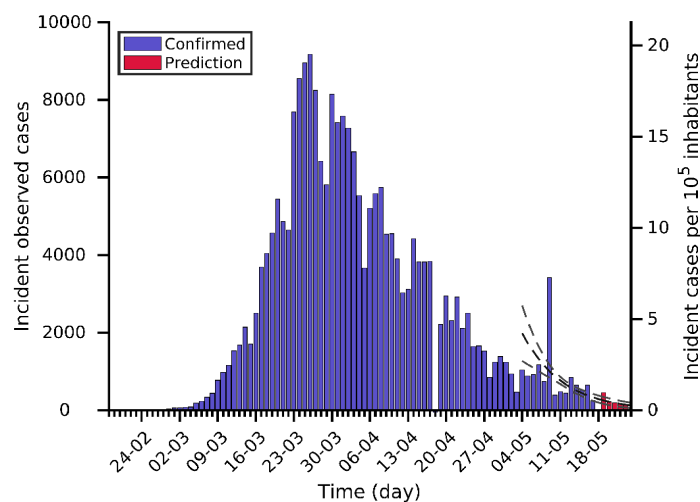
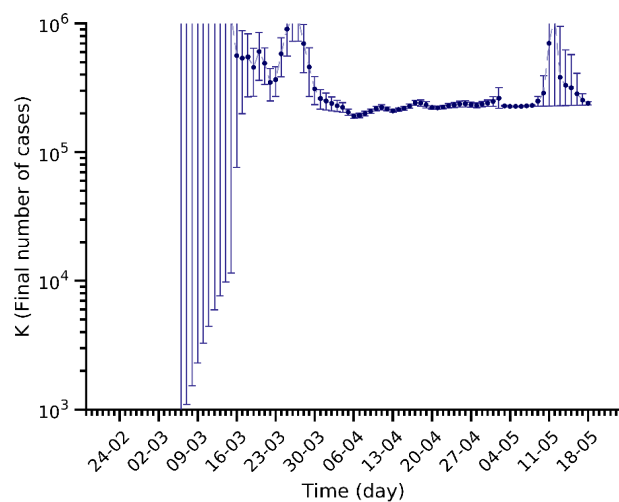
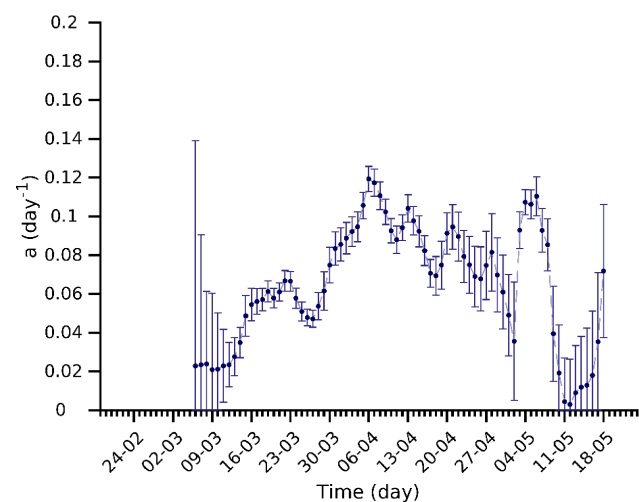
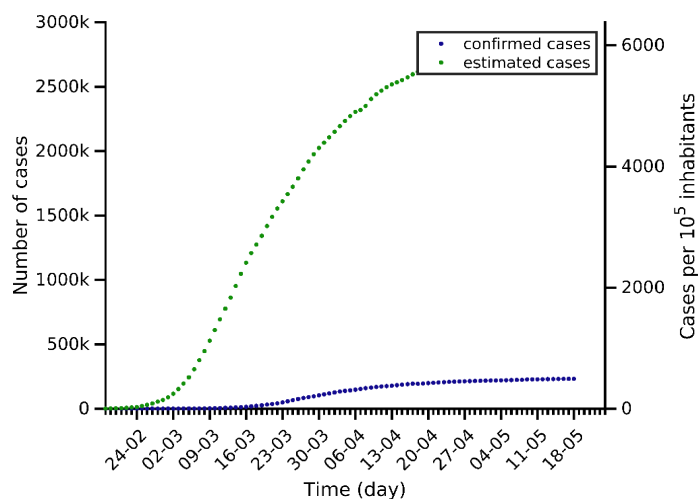
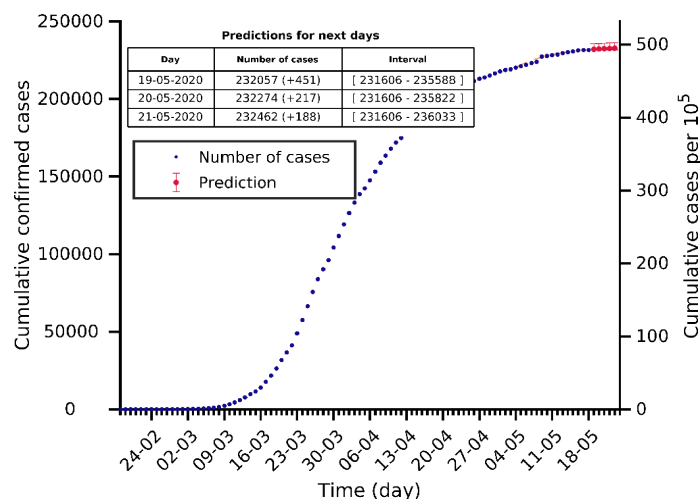
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>



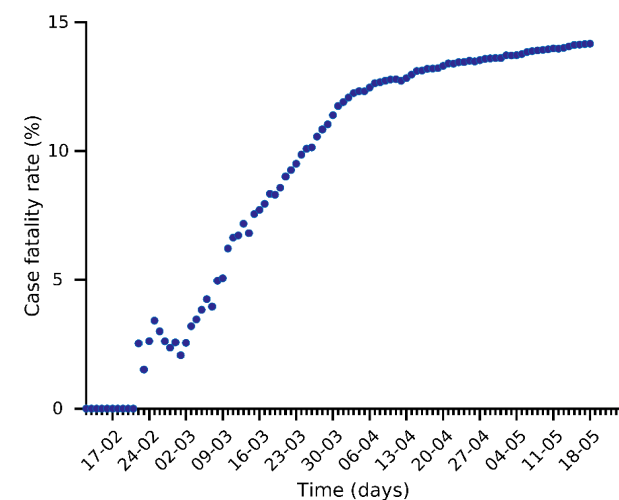
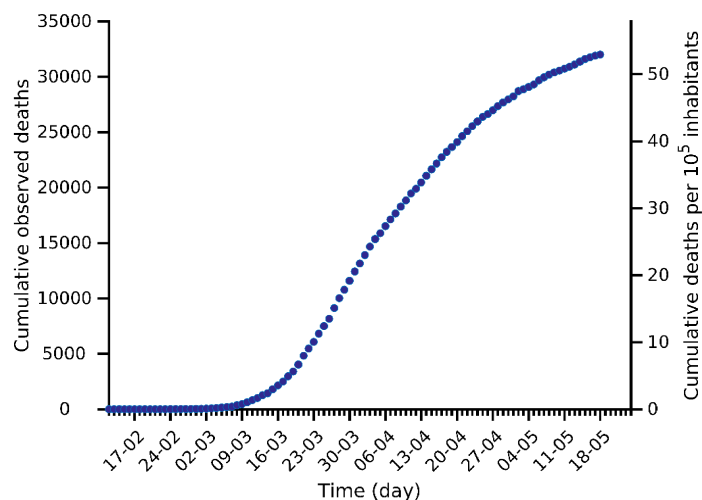
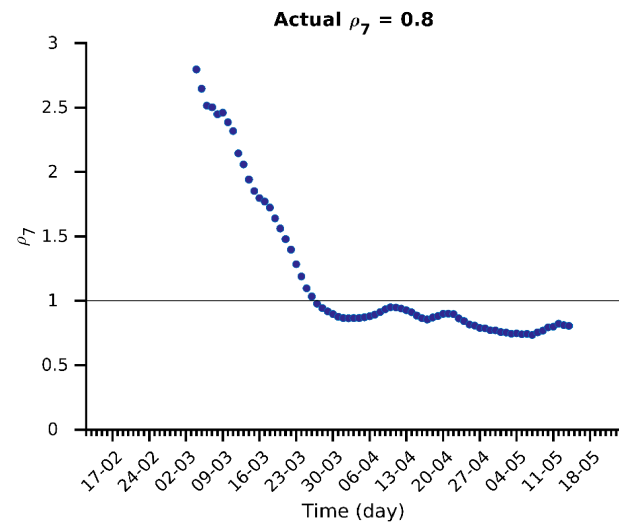
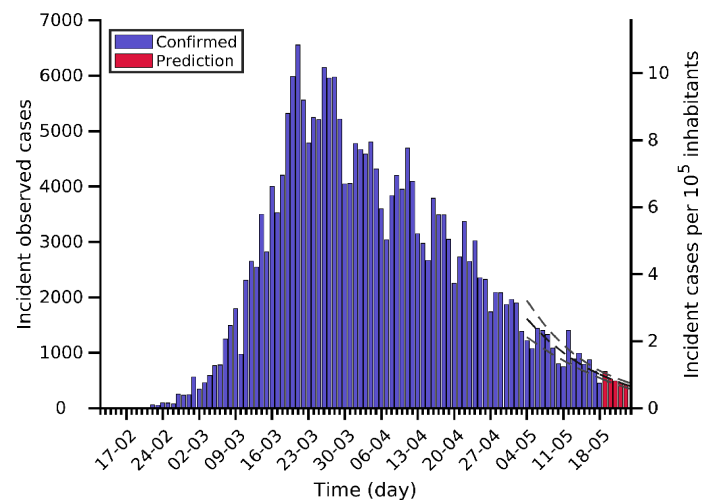
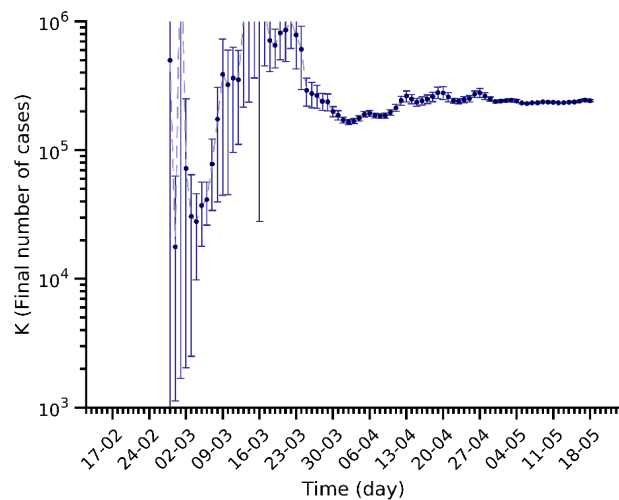
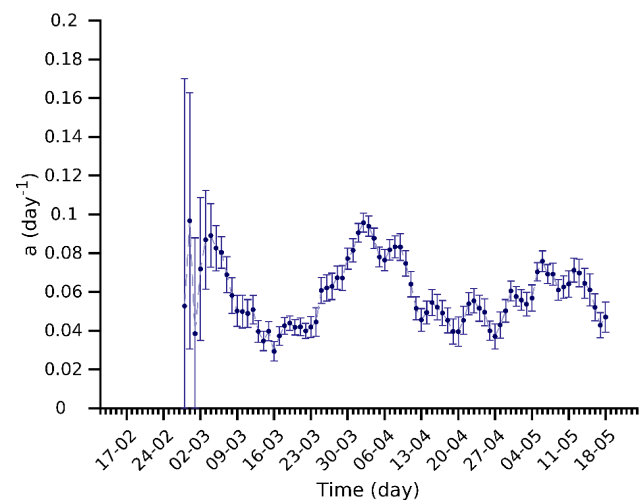
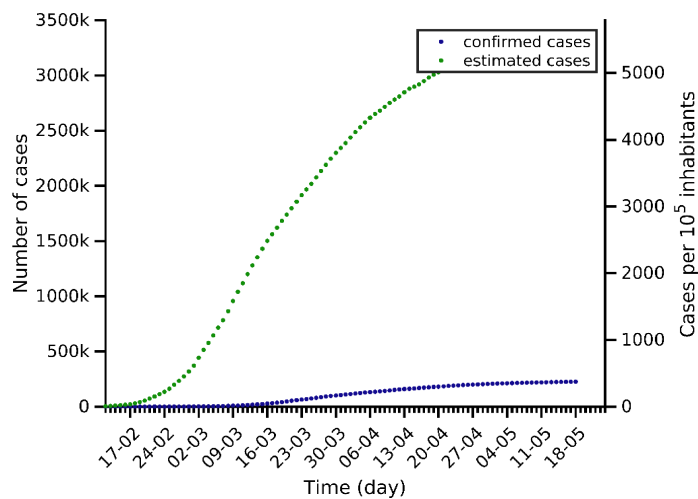
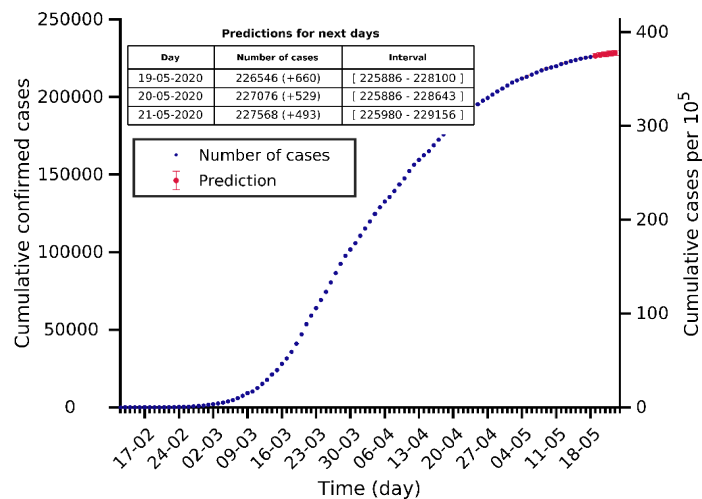
UK 18-05-2020. Population: 67.9M. Current cumulated incidence: 363/10⁵



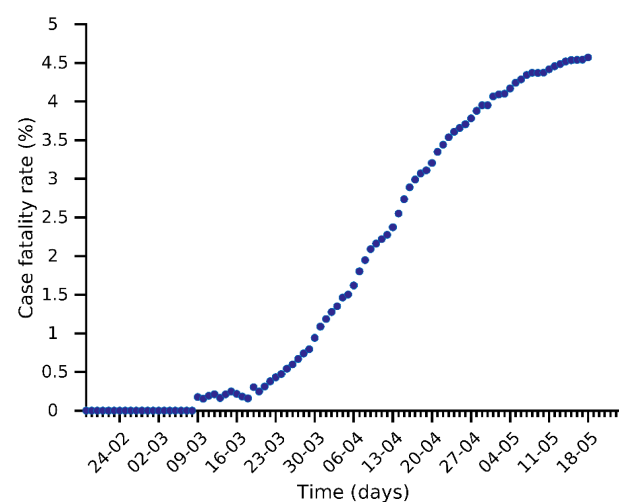
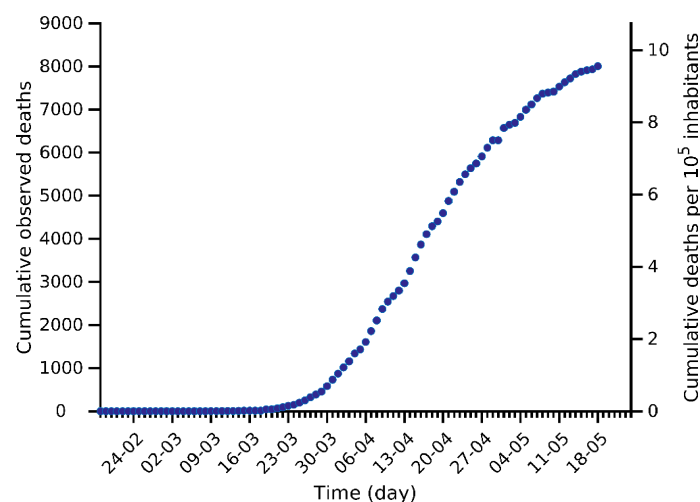
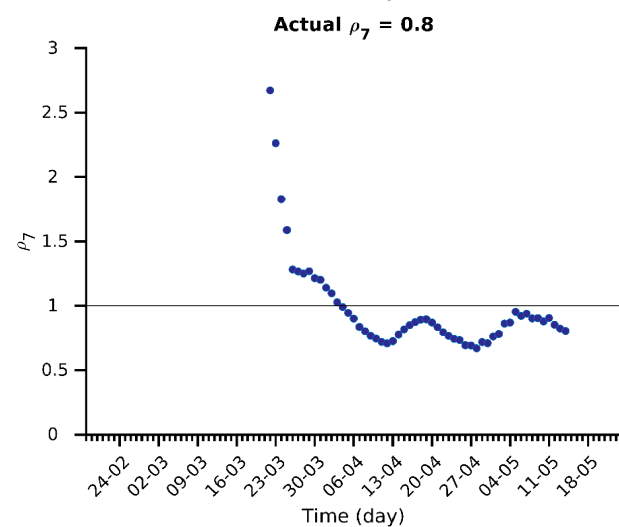
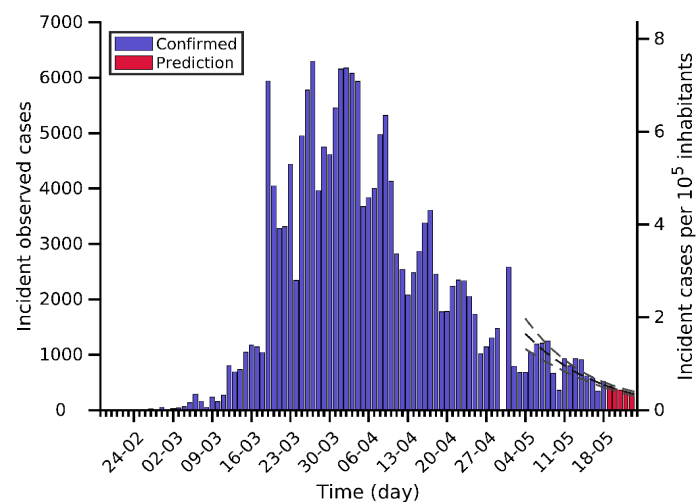
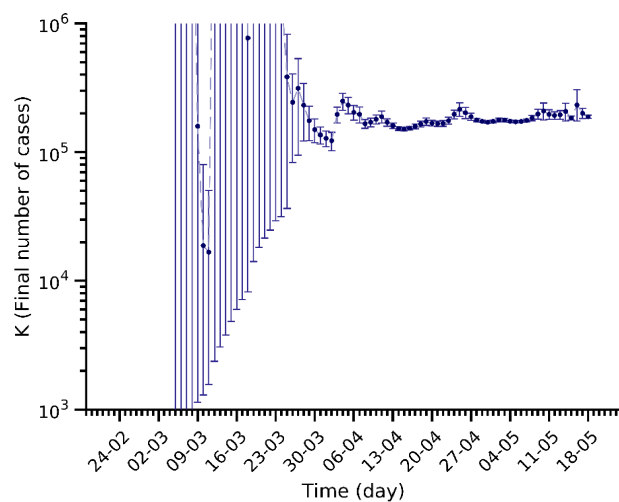
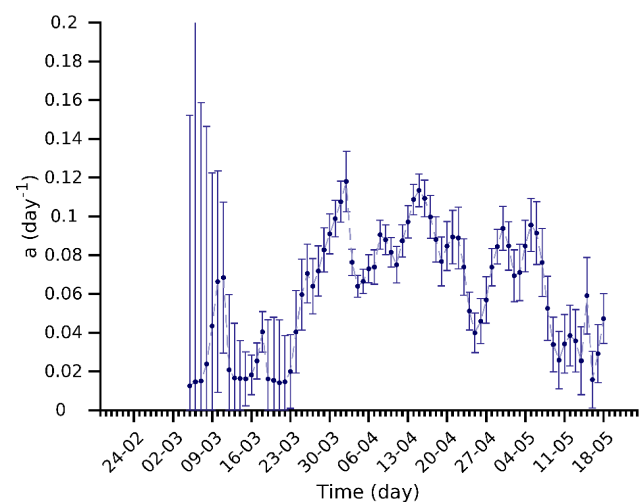
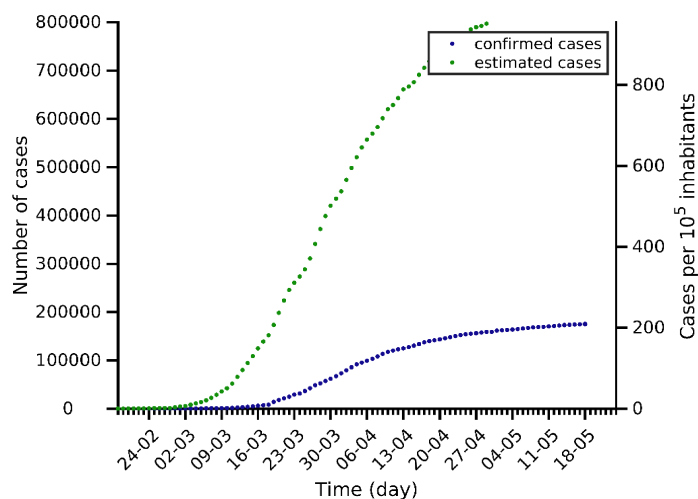
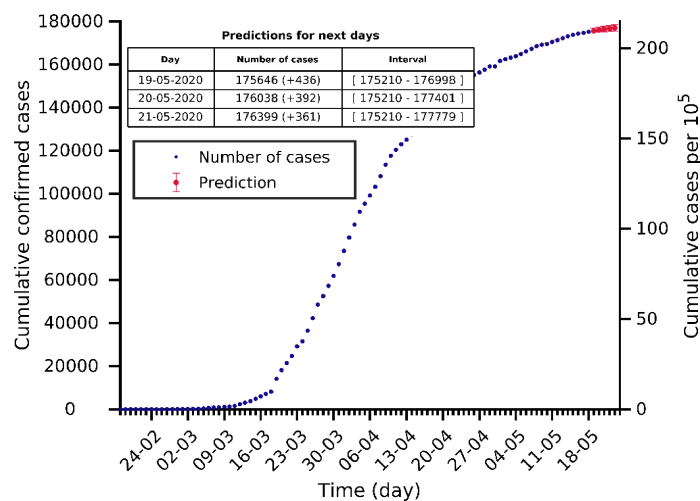
Spain 18-05-2020. Population: 47.0M. Current cumulated incidence: 493/10⁵



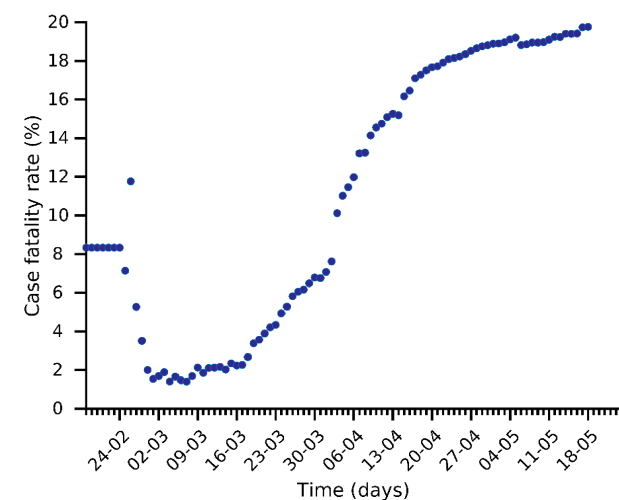
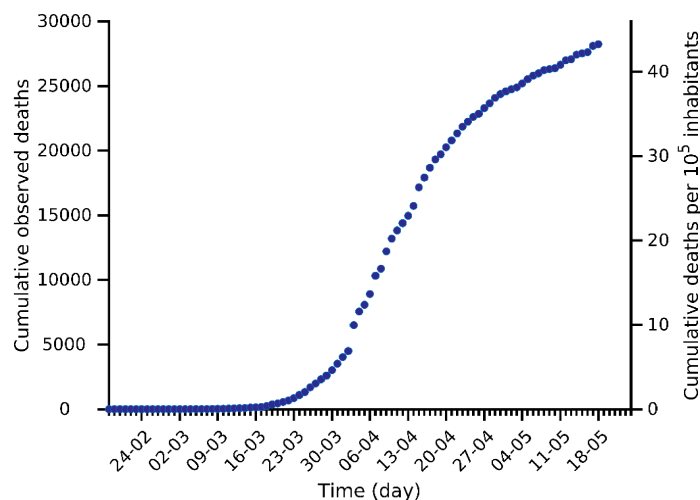
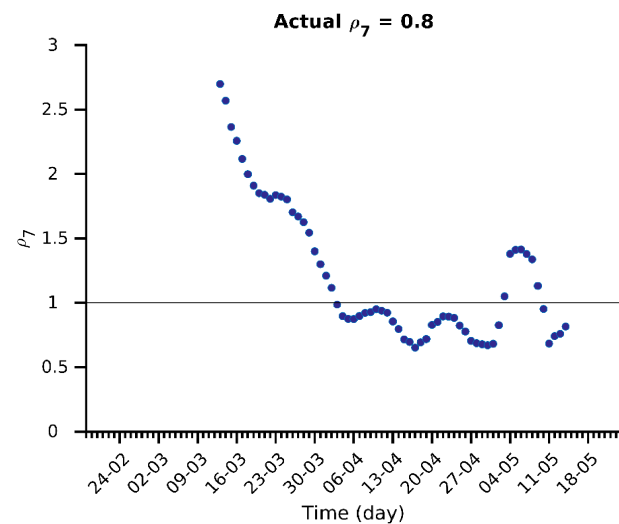
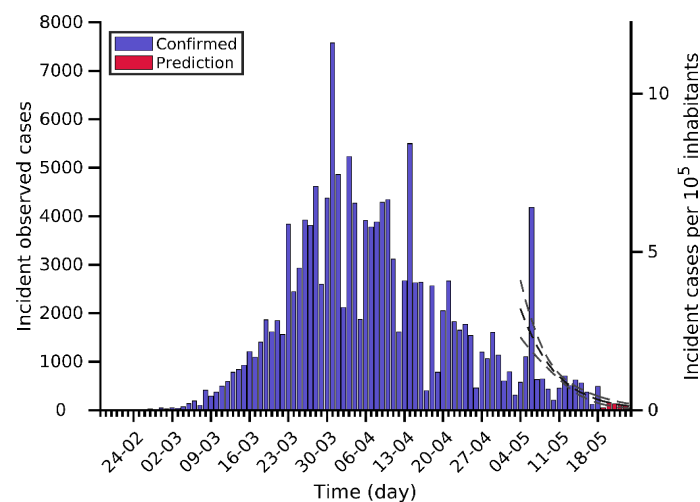
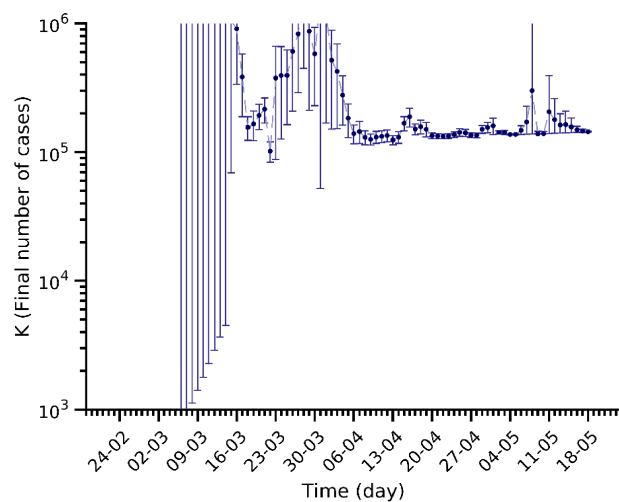
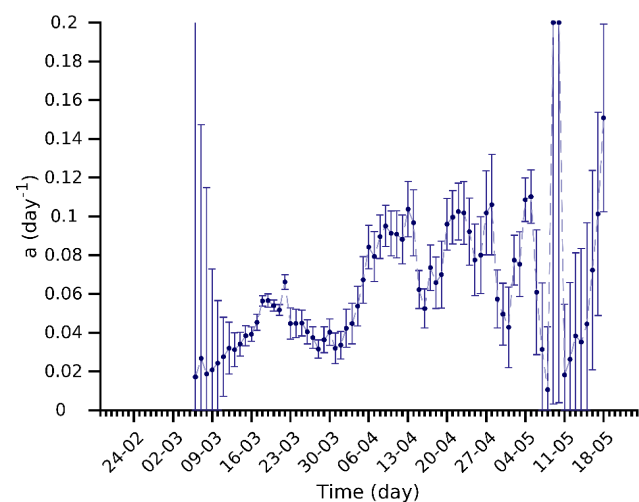
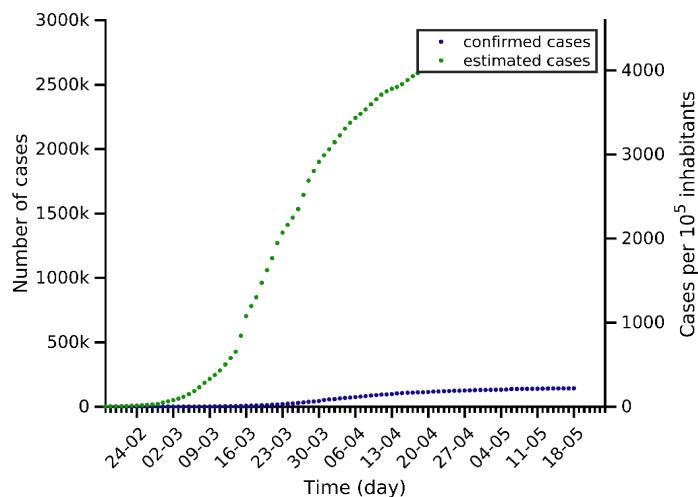
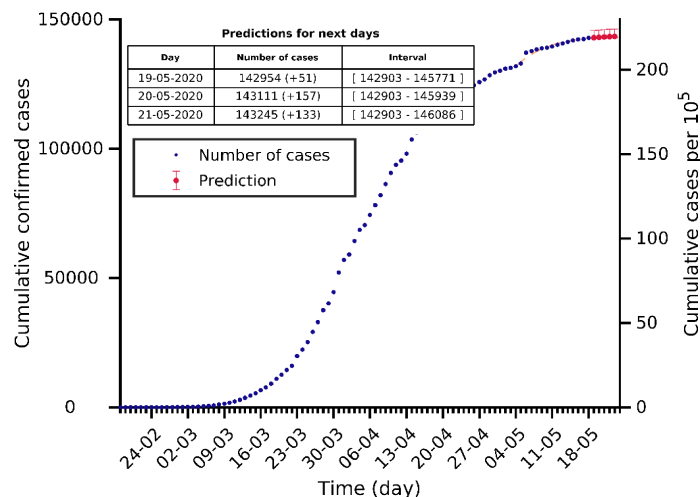
Italy 18-05-2020. Population: 60.5M. Current cumulated incidence: 374/10⁵



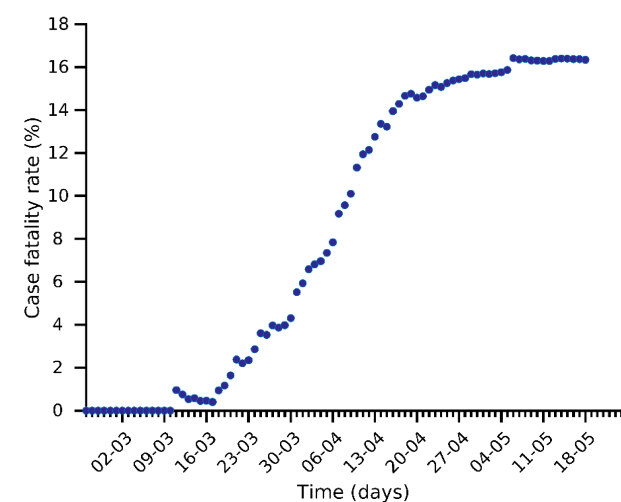
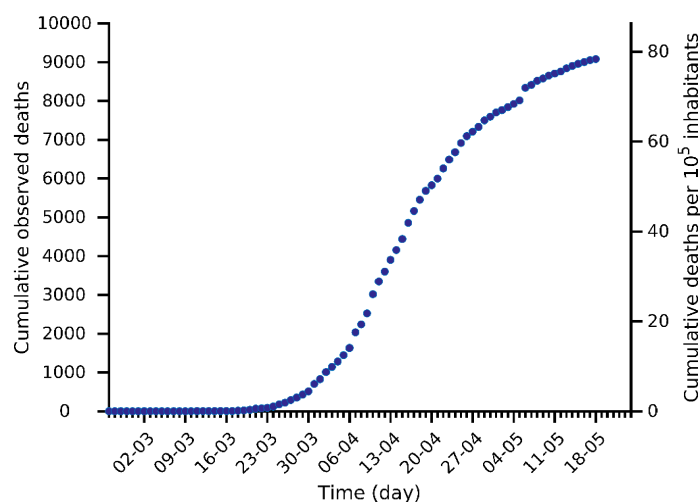
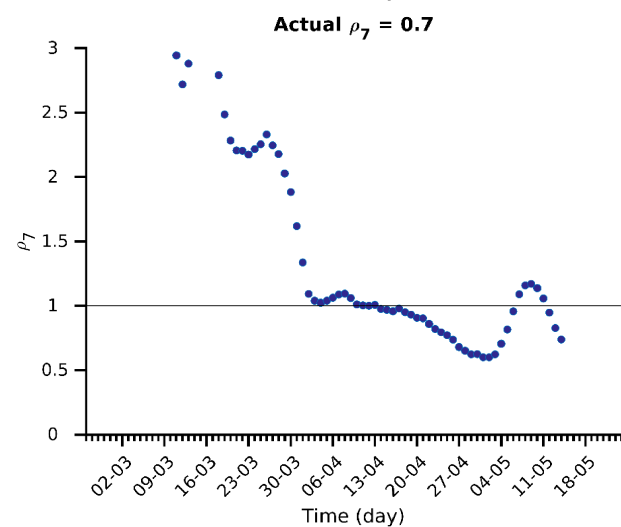
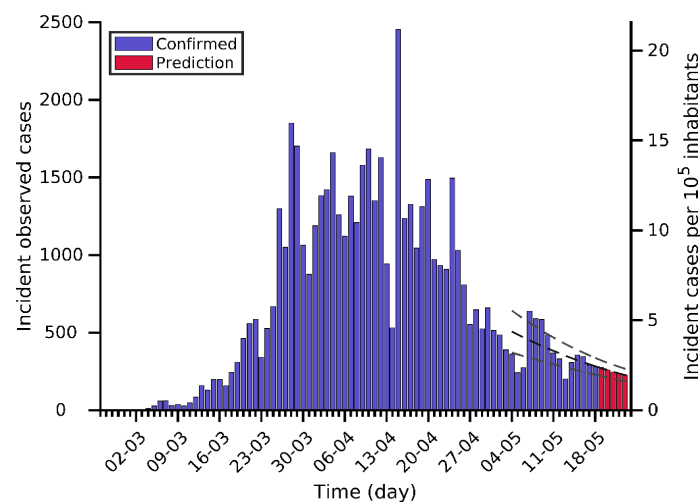
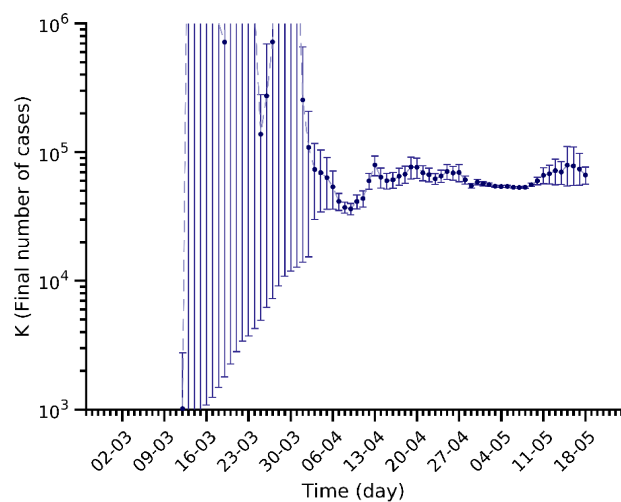
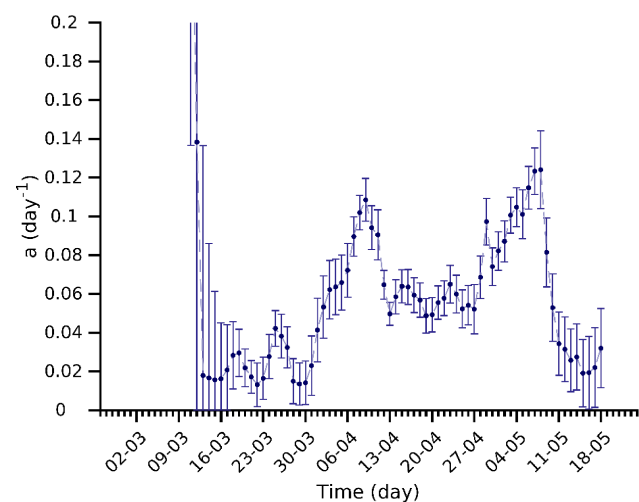
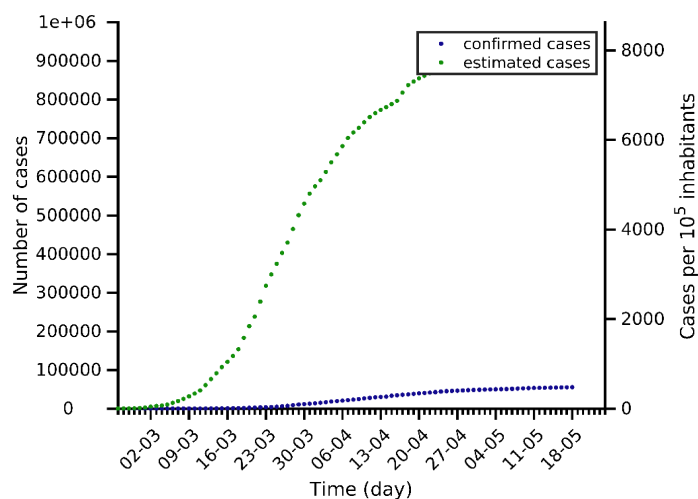
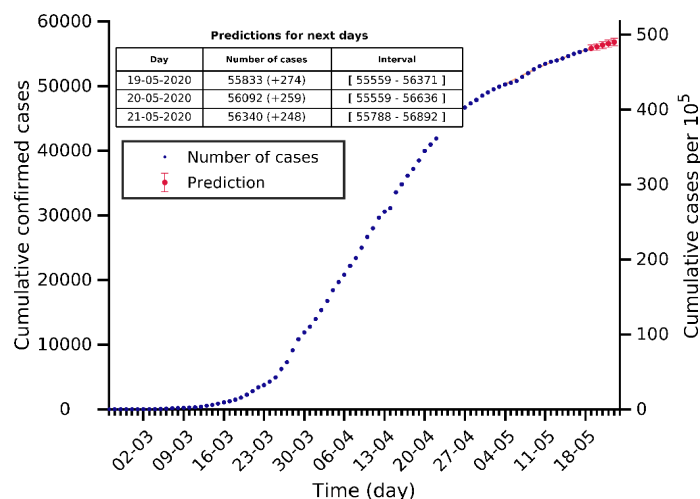
Germany 18-05-2020. Population: 83.8M. Current cumulated incidence: 209/10⁵



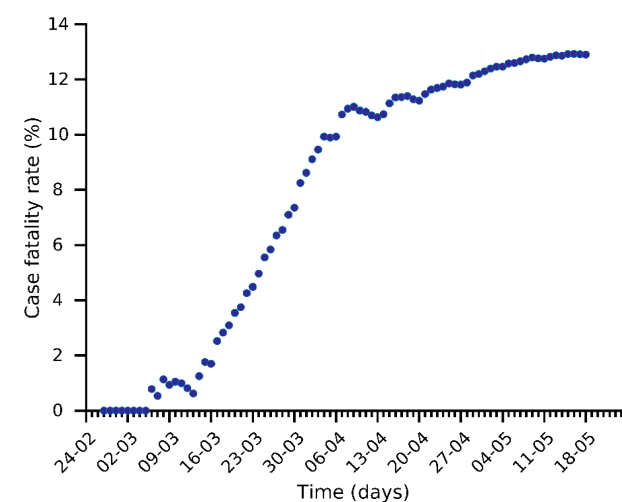
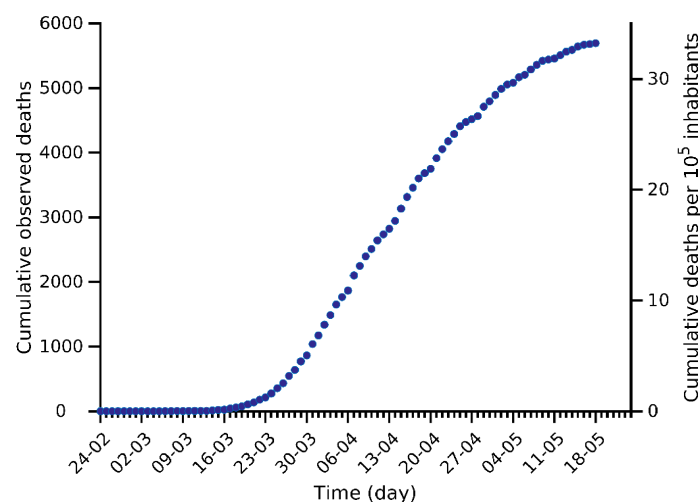
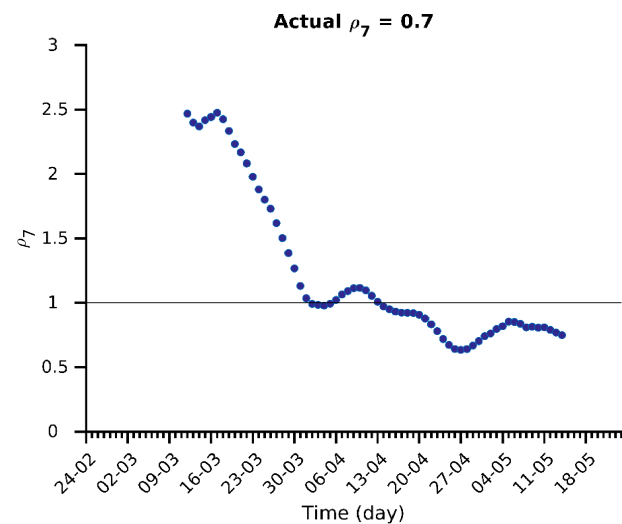
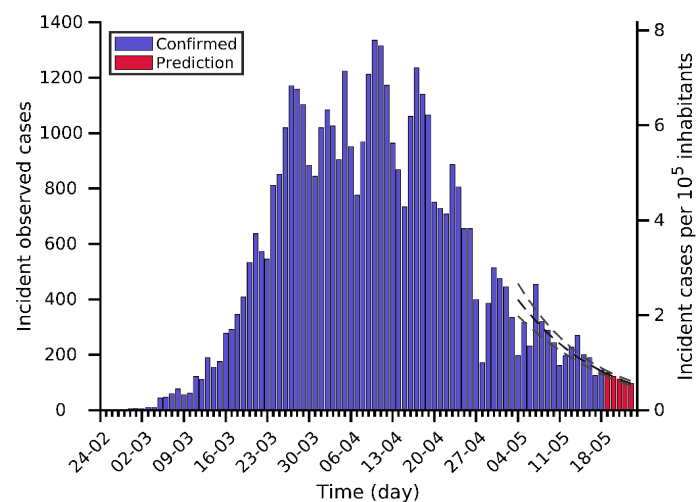
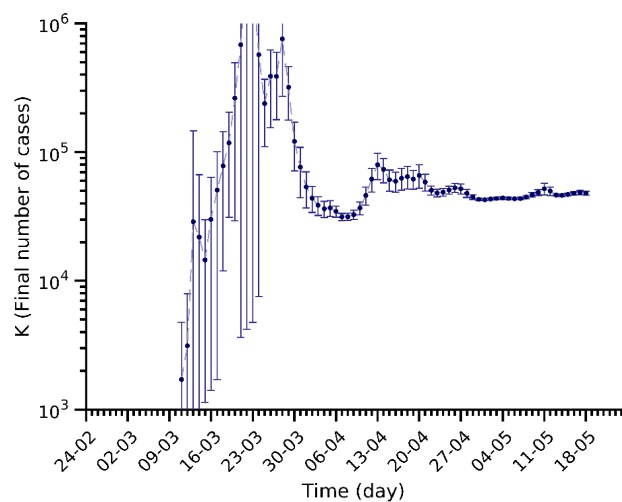
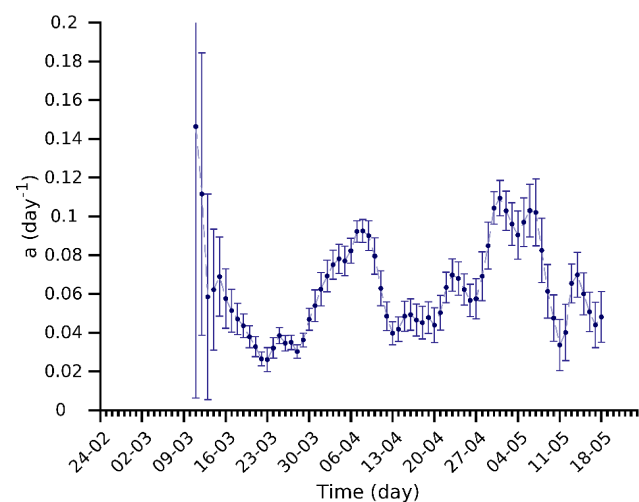
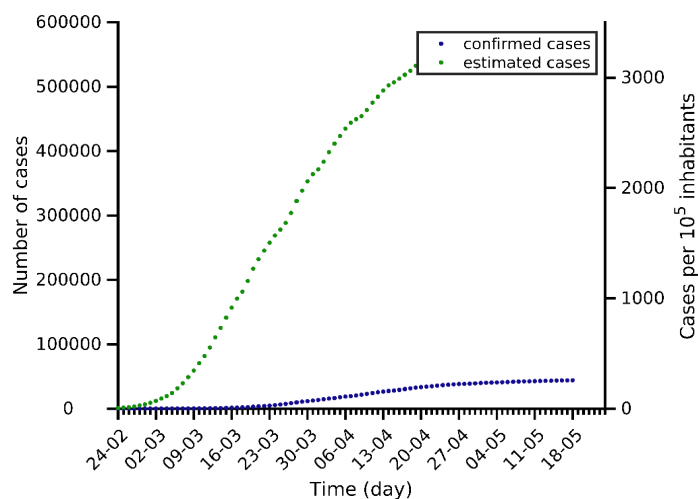
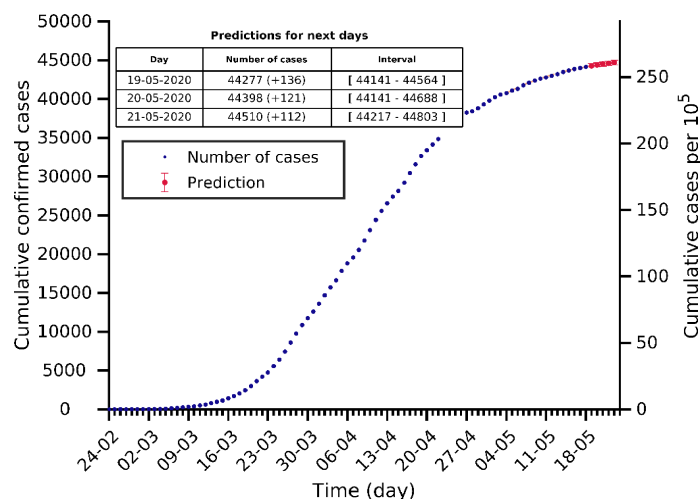
France 18-05-2020. Population: 65.3M. Current cumulated incidence: 219/10⁵



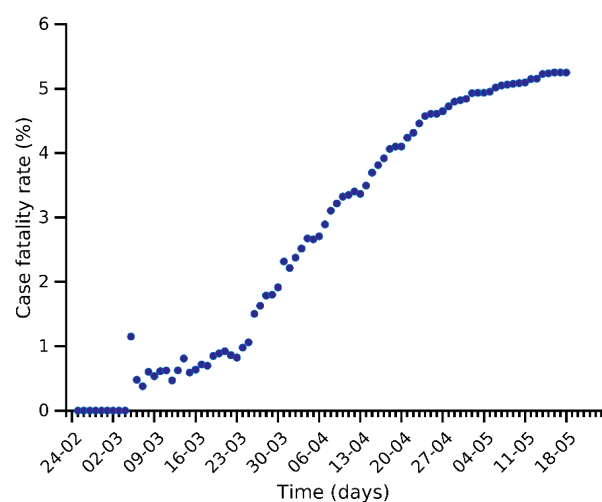
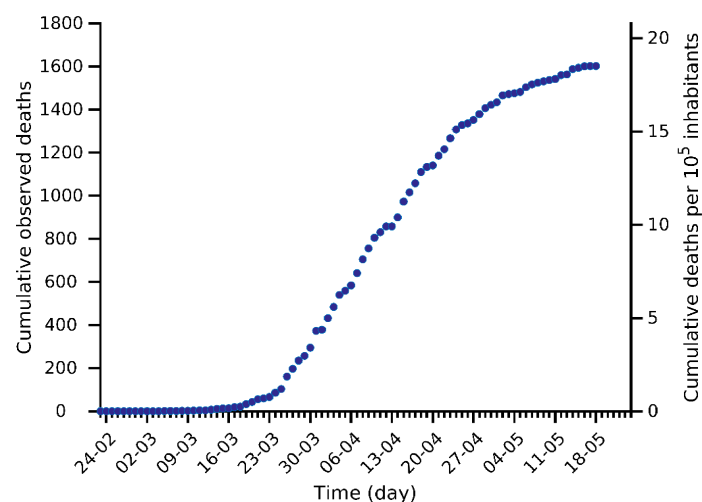
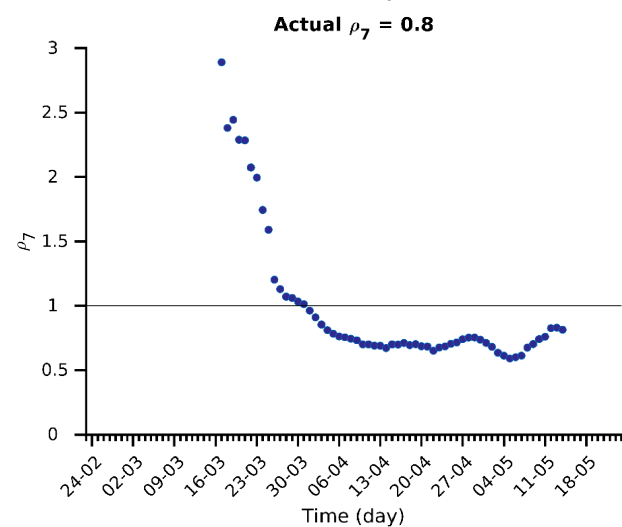
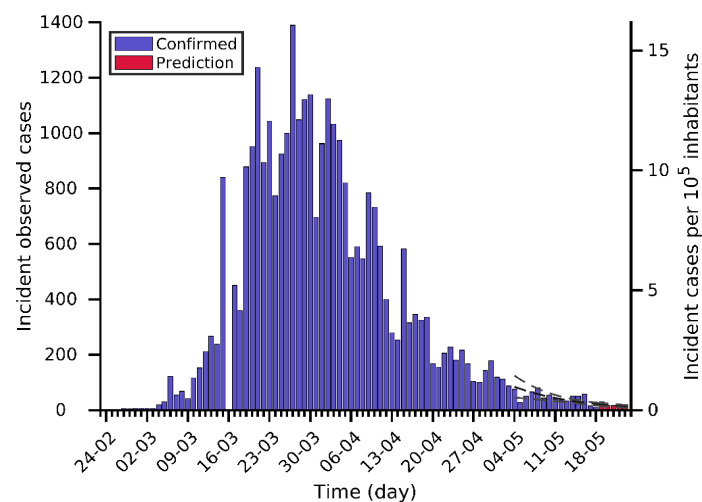
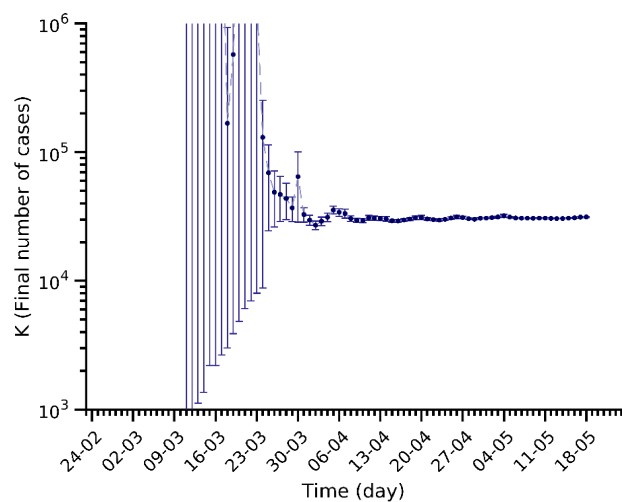
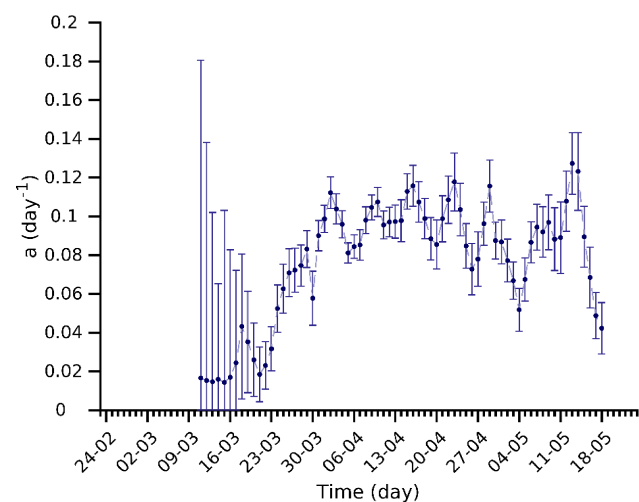
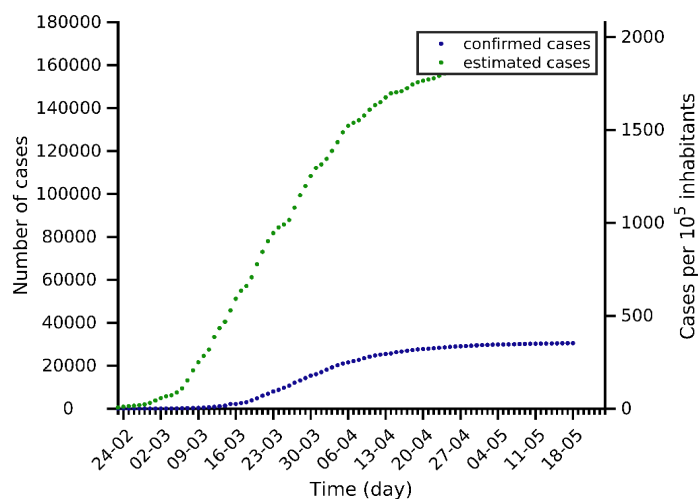
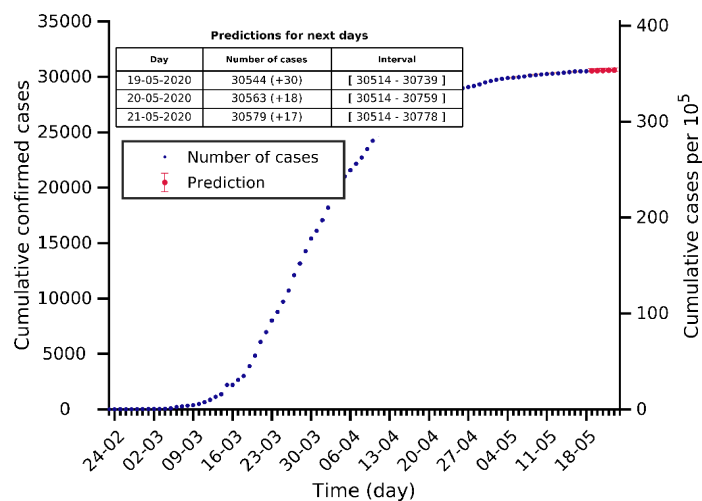
Belgium 18-05-2020. Population: 11.6M. Current cumulated incidence: 479/10⁵



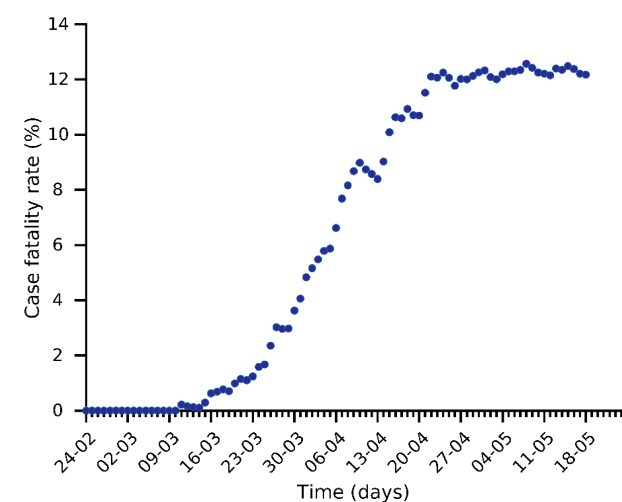
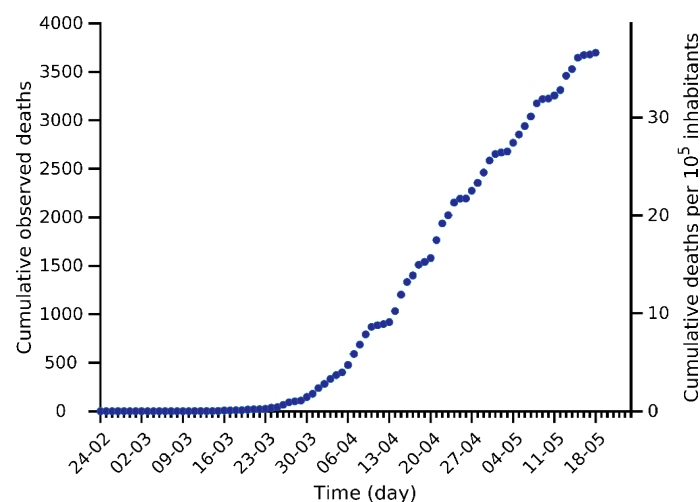
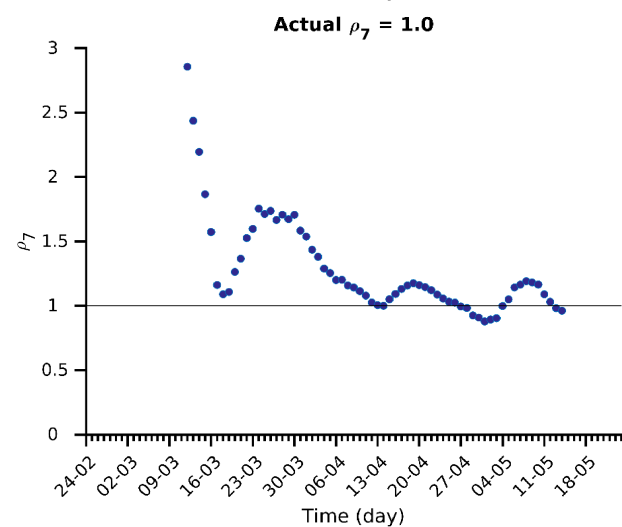
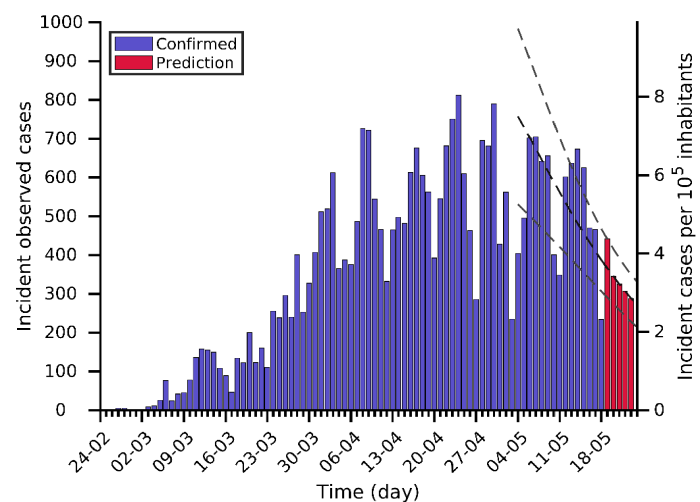
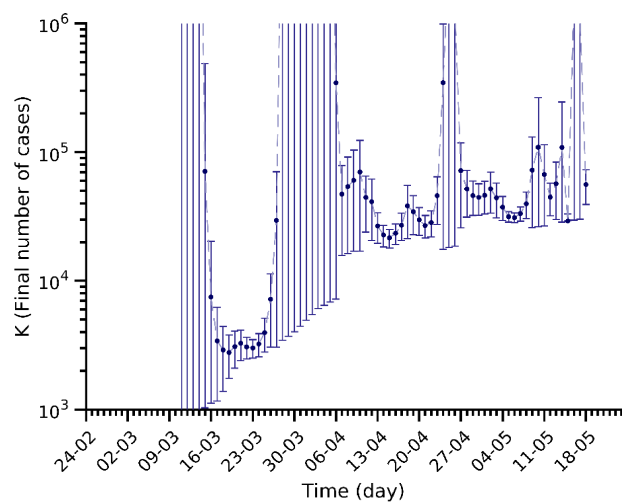
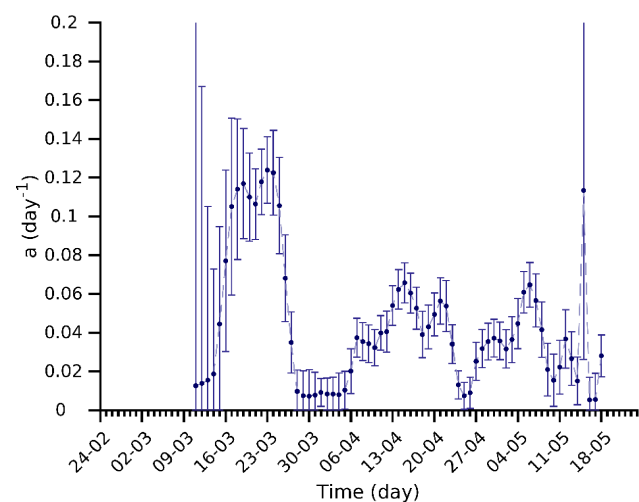
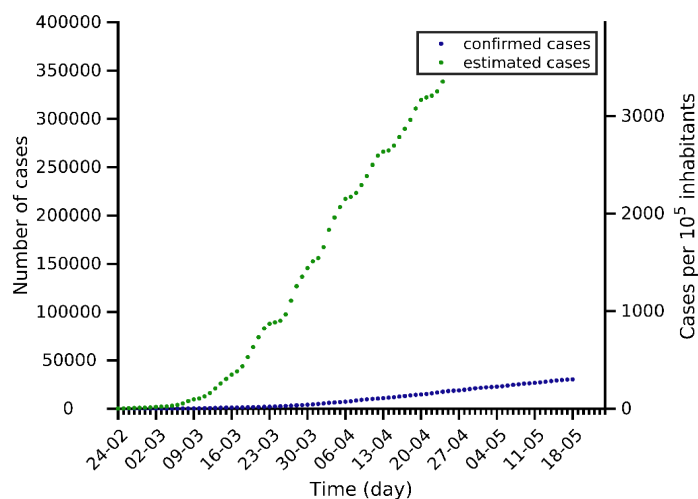
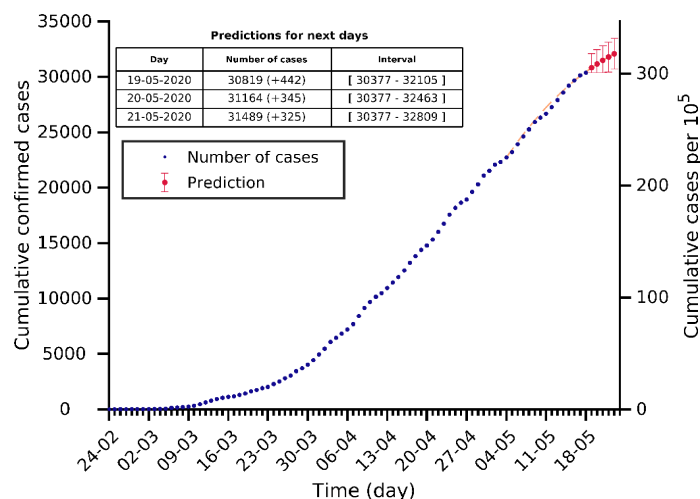
Netherlands 18-05-2020. Population: 17.1M. Current cumulated incidence: 258/10⁵



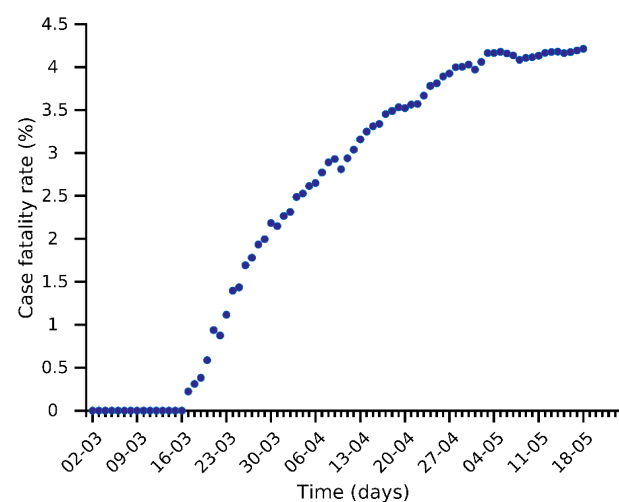
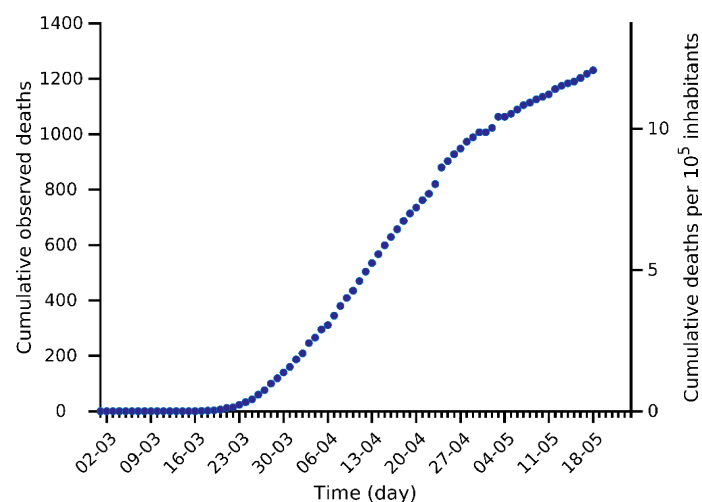
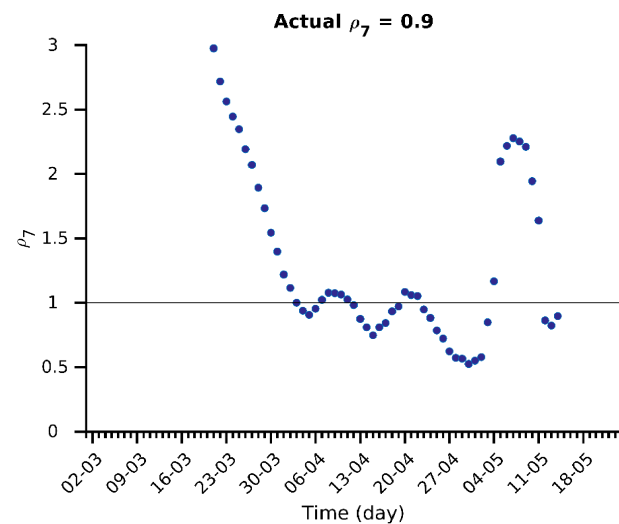
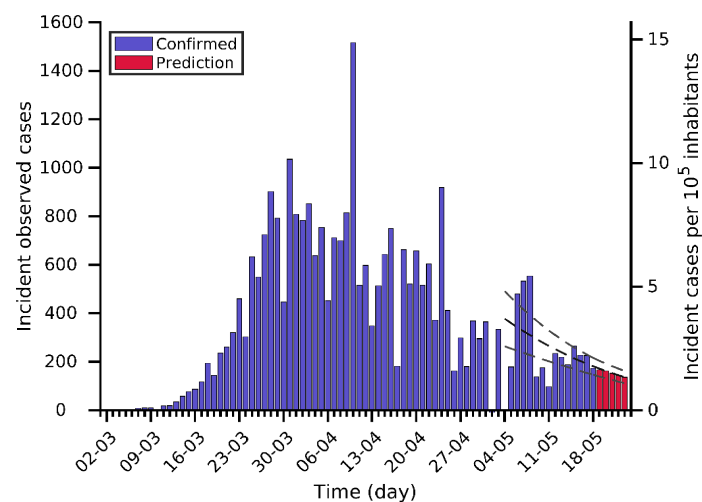
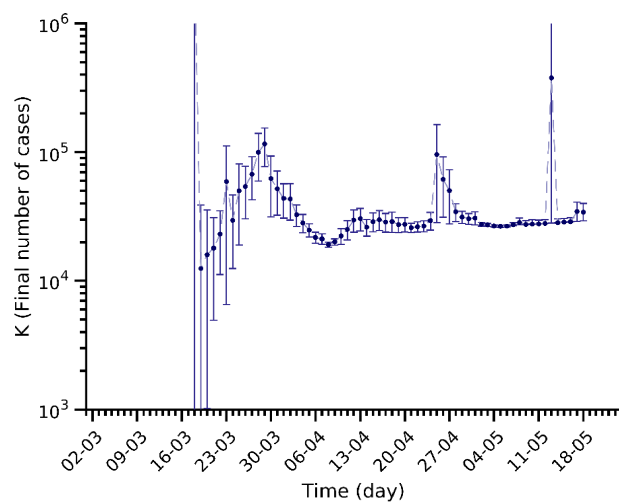
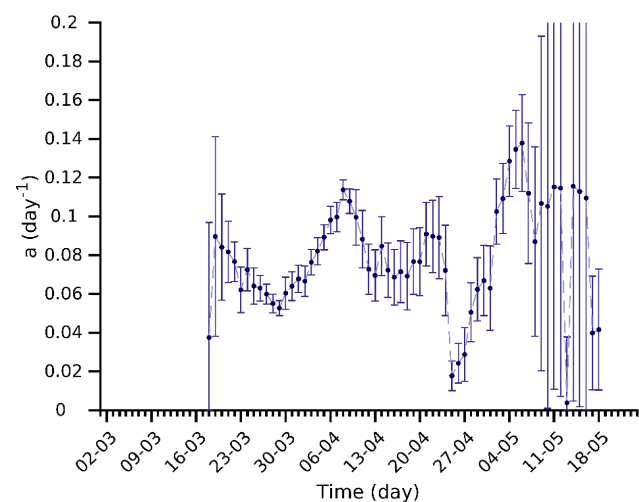
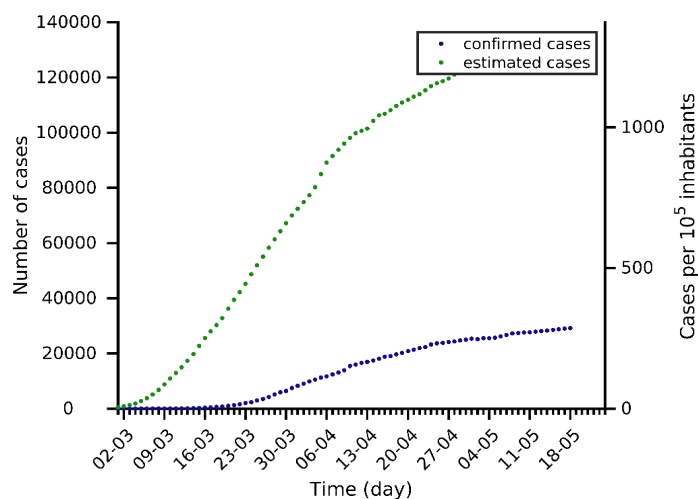
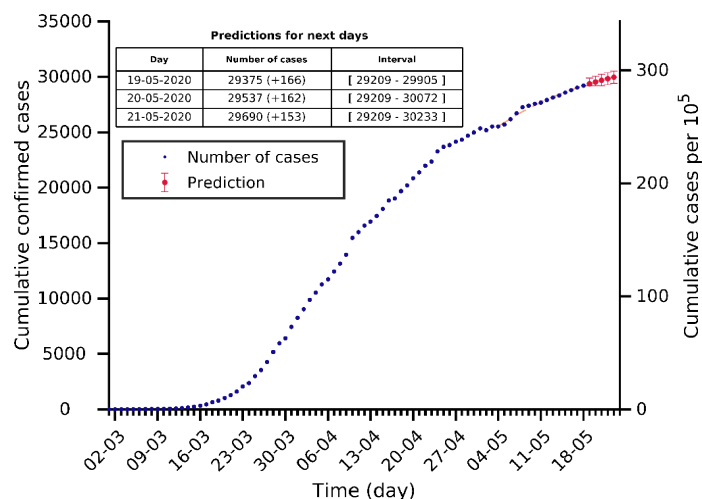
Switzerland 18-05-2020. Population: 8.7M. Current cumulated incidence: 353/10⁵



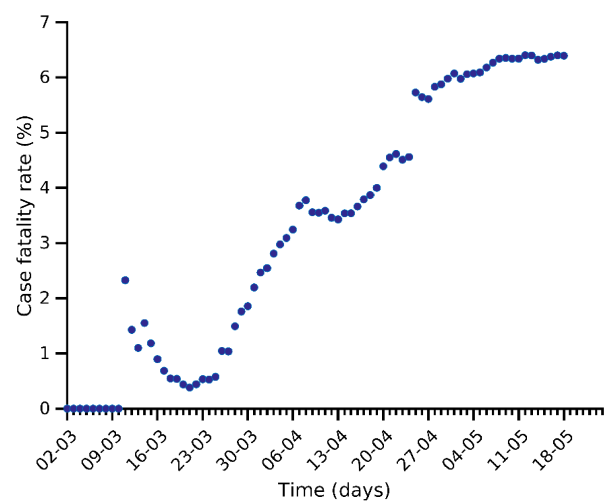
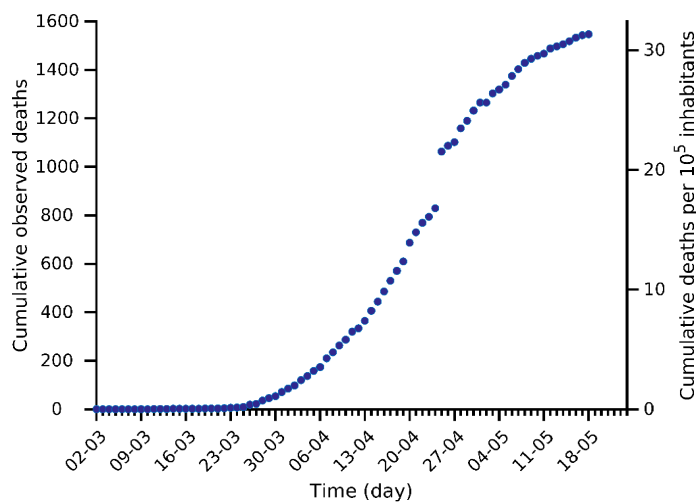
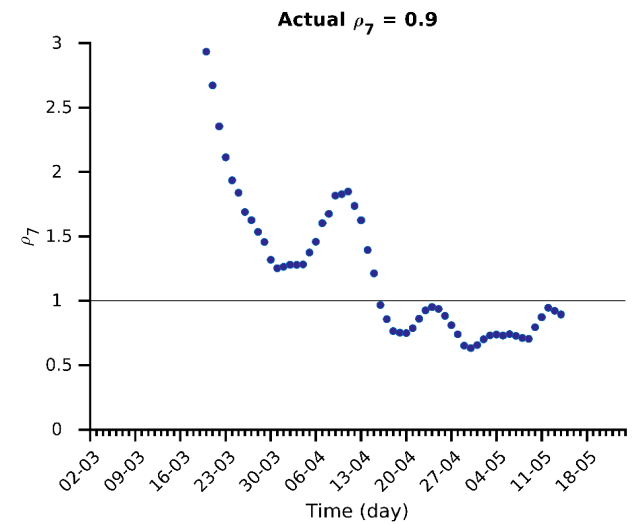
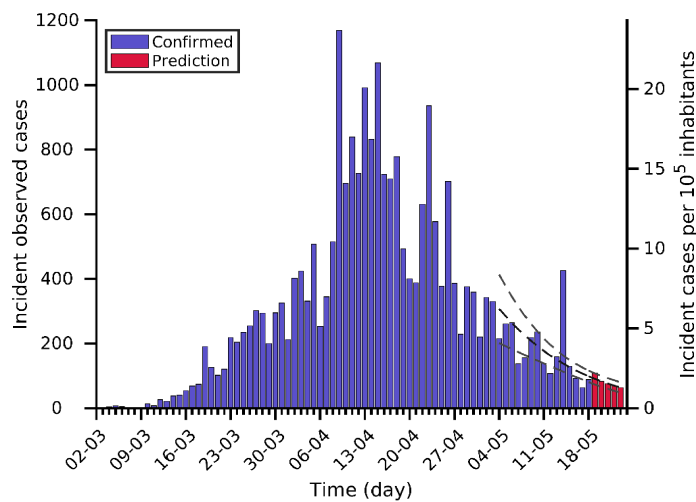
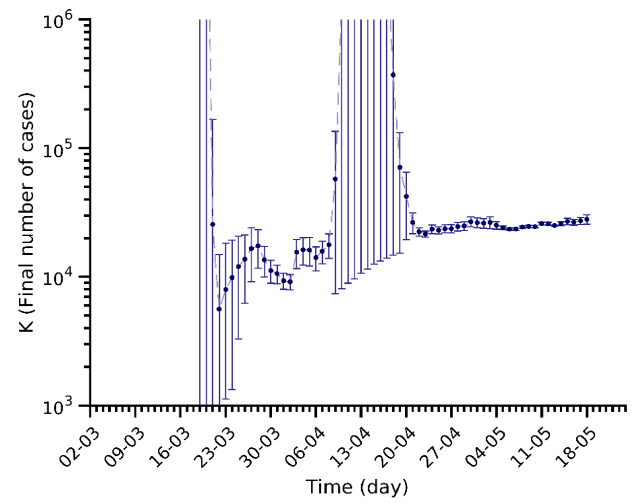
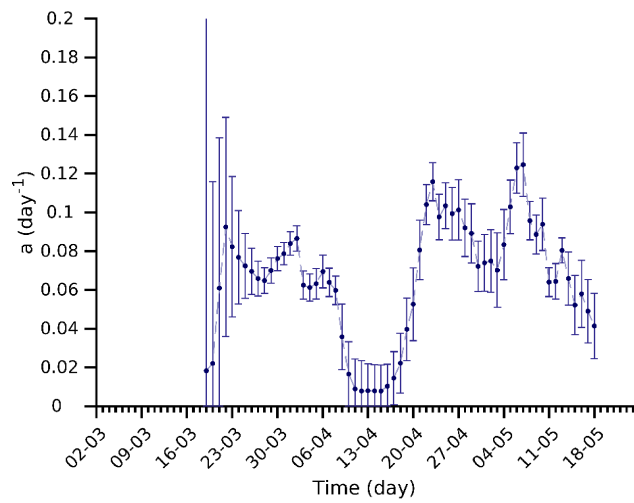
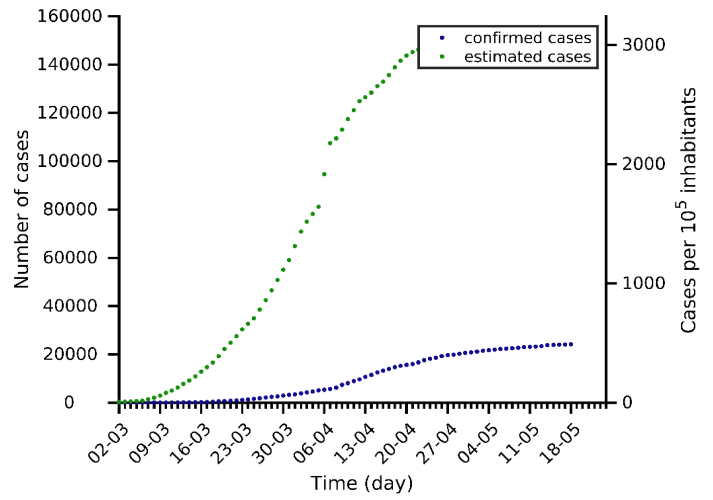
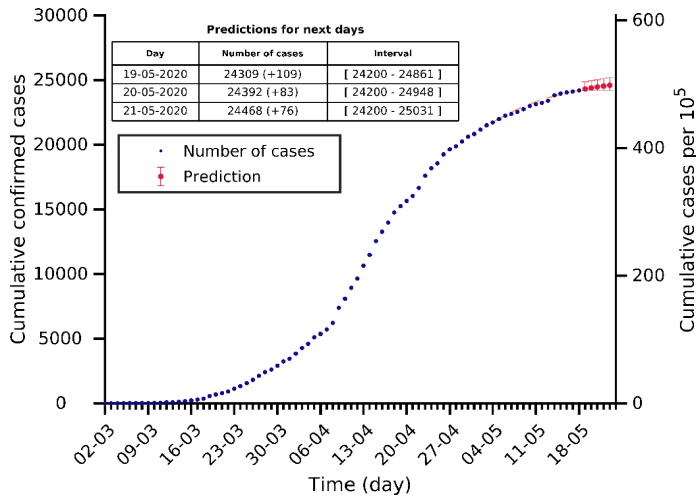
Sweden 18-05-2020. Population: 10.1M. Current cumulated incidence: 301/10⁵



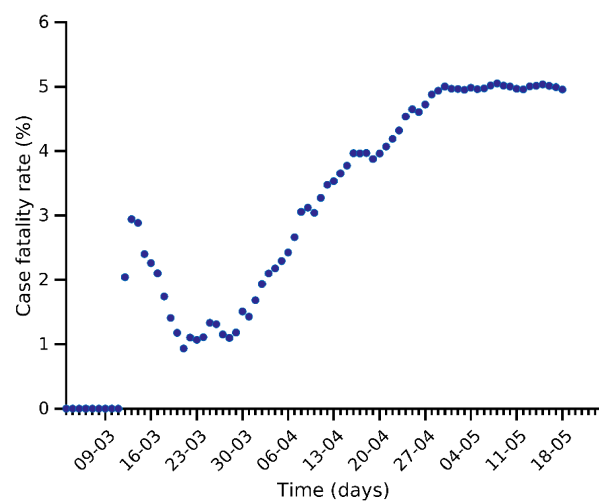
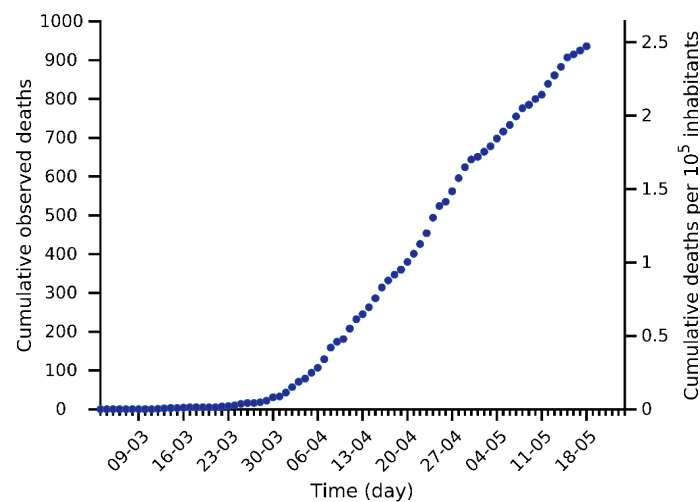
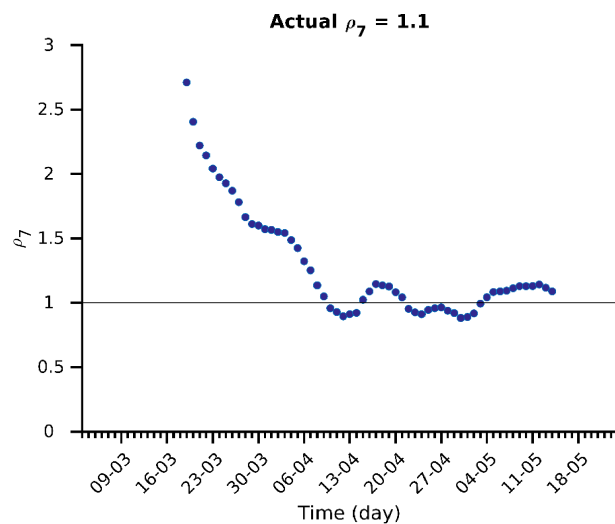
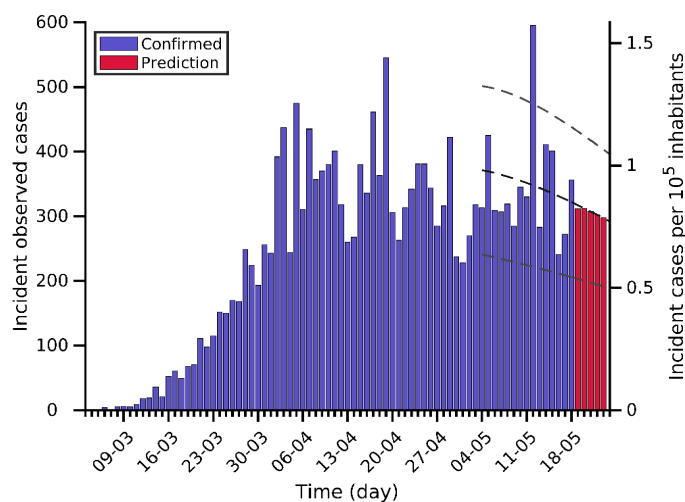
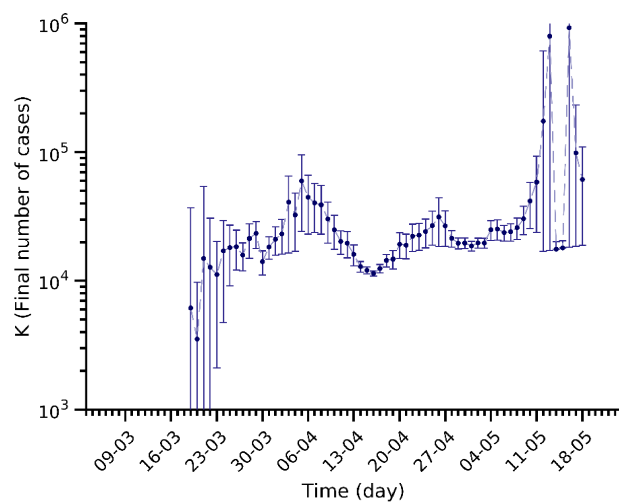
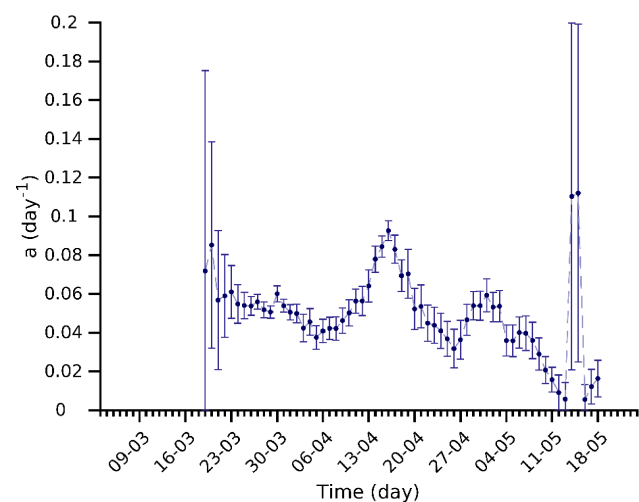
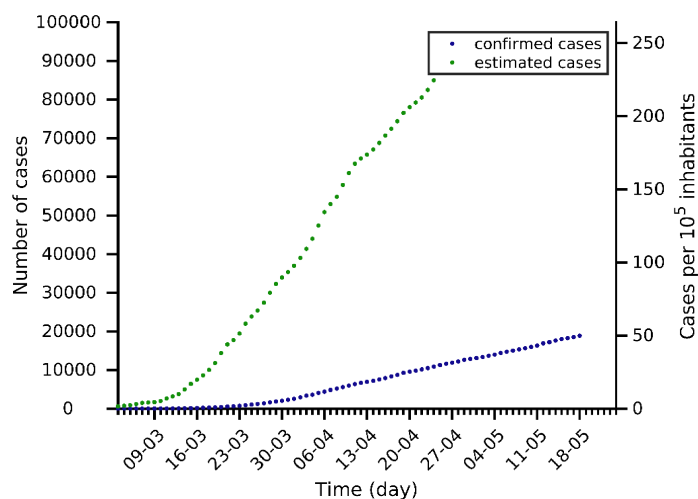
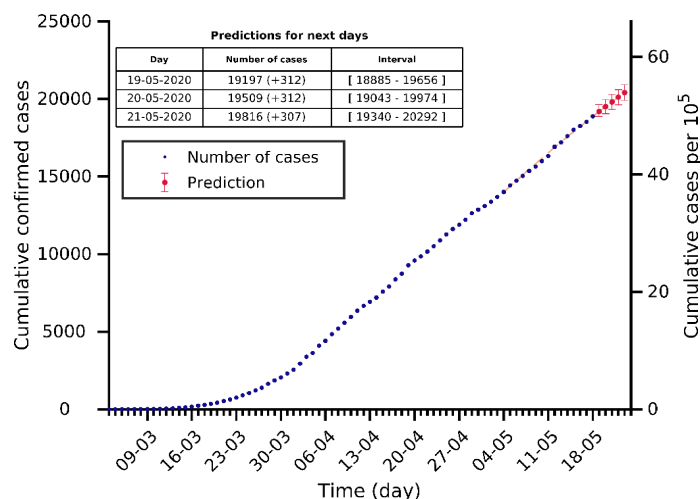
Portugal 18-05-2020. Population: 10.2M. Current cumulated incidence: 286/10⁵



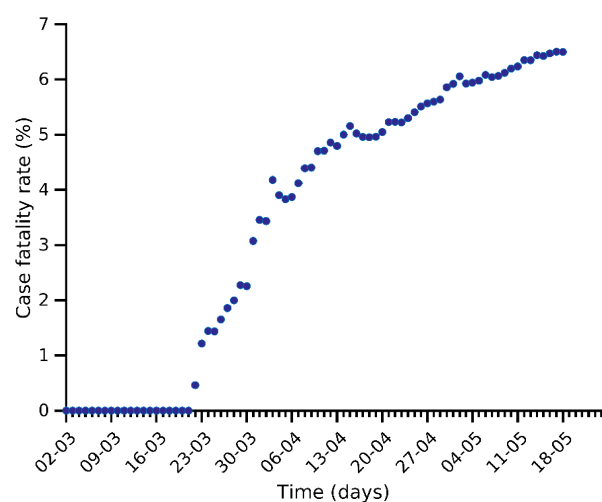
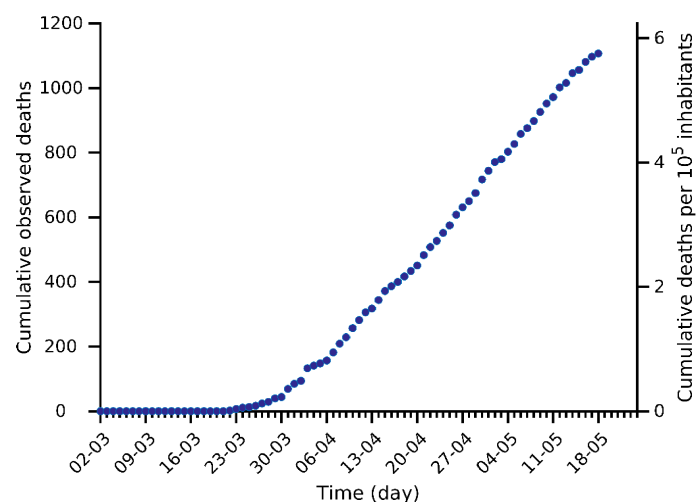
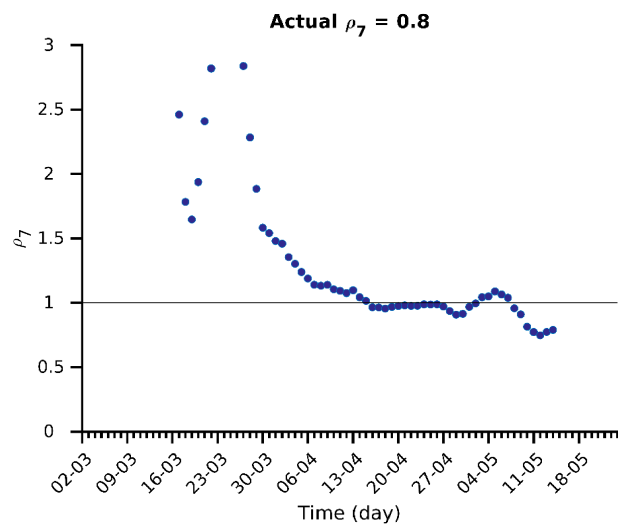
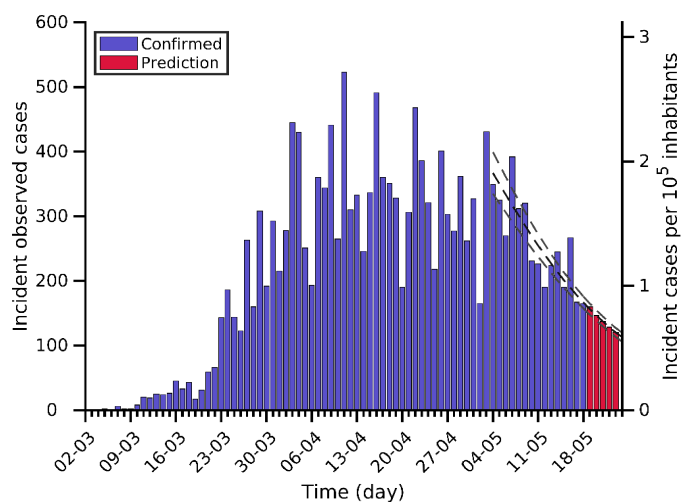
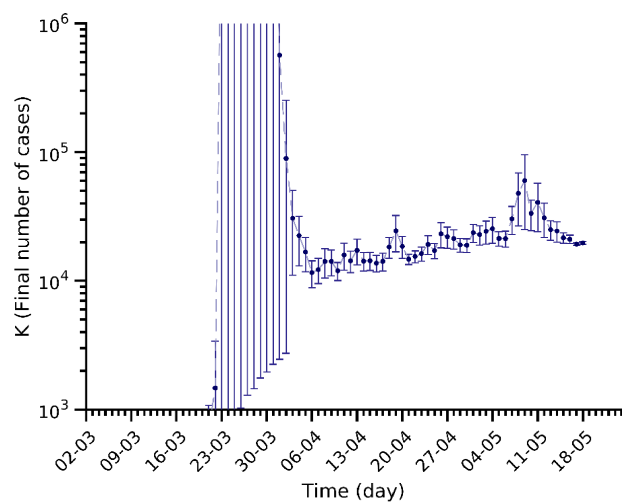
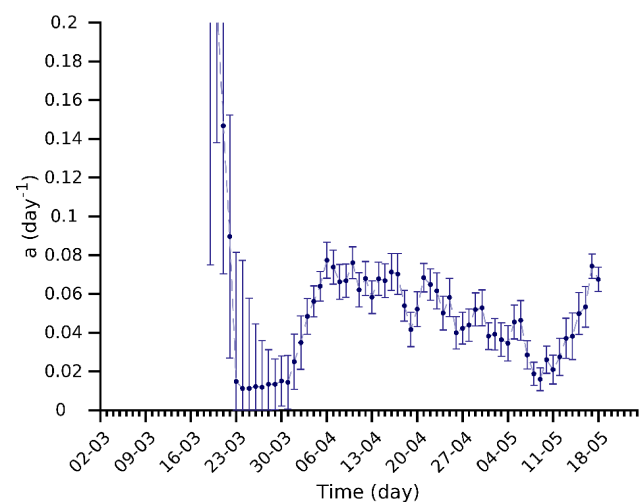
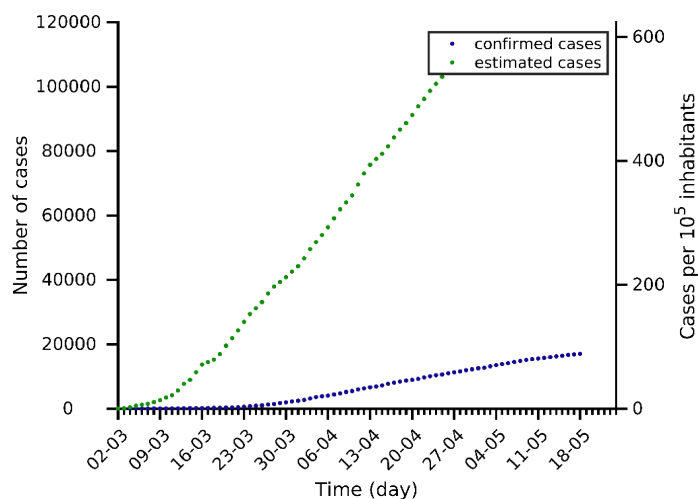
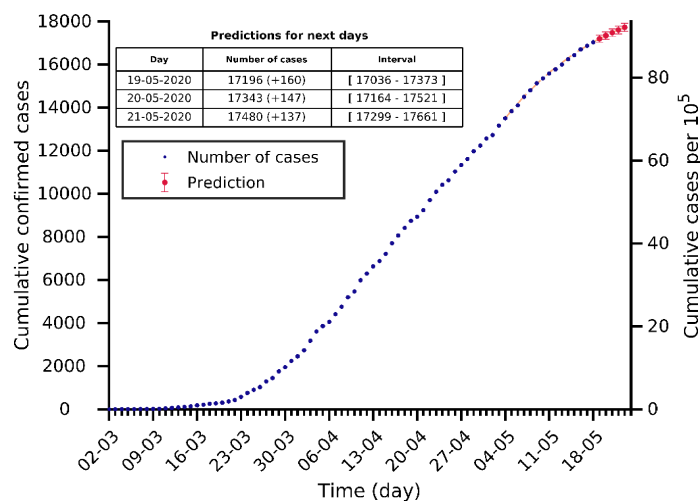
Ireland 18-05-2020. Population: 4.9M. Current cumulated incidence: 490/10⁵



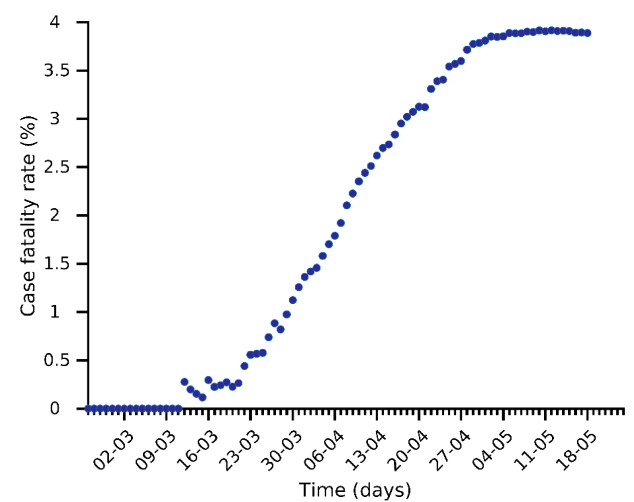
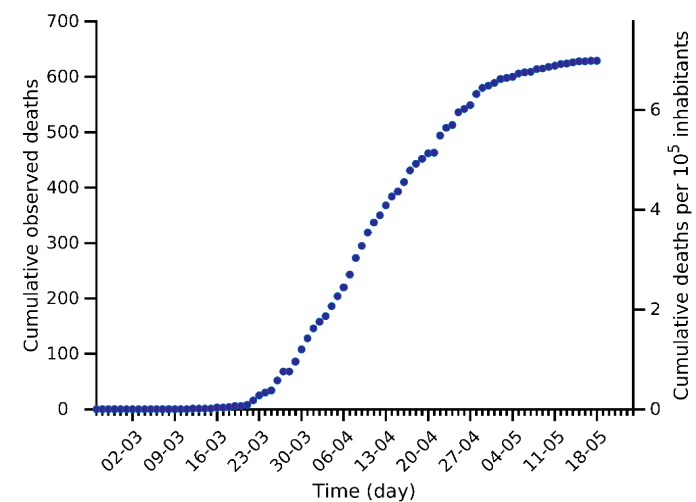
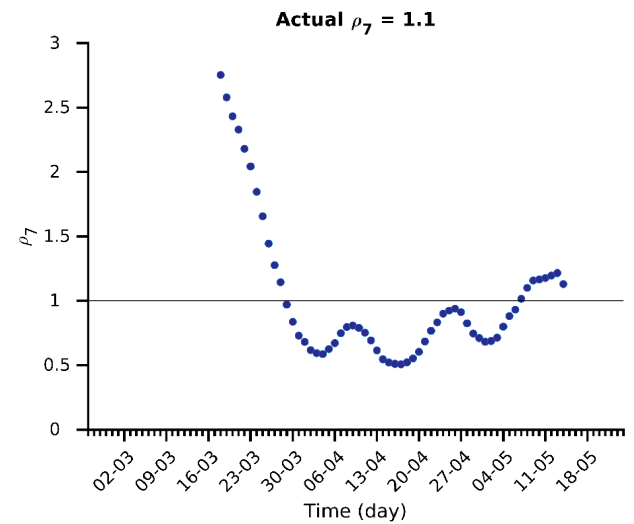
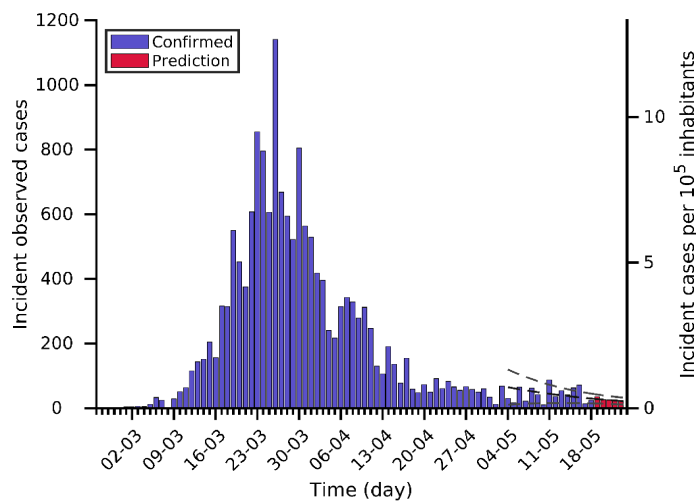
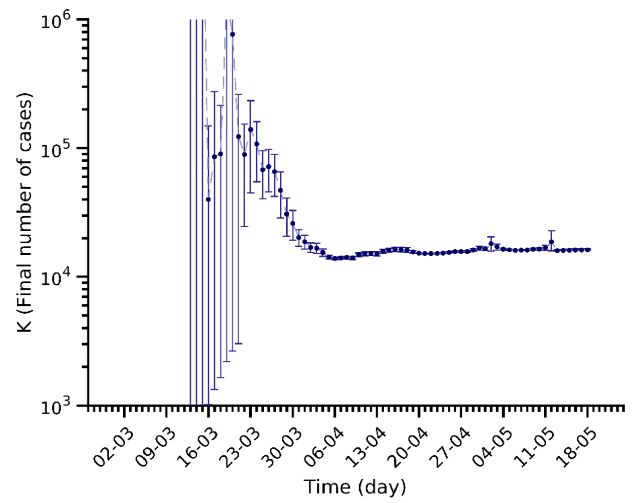
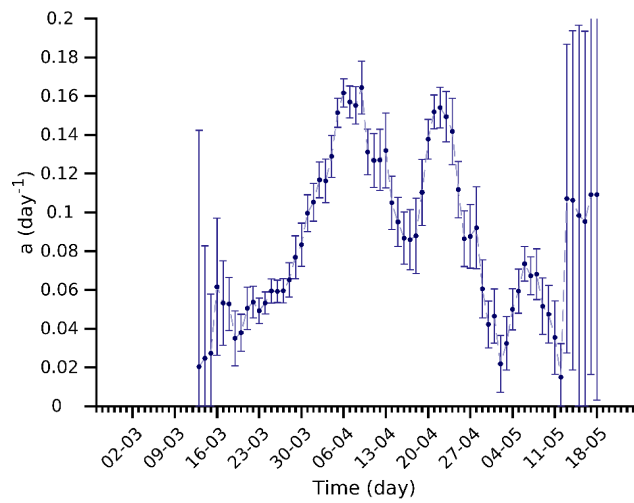
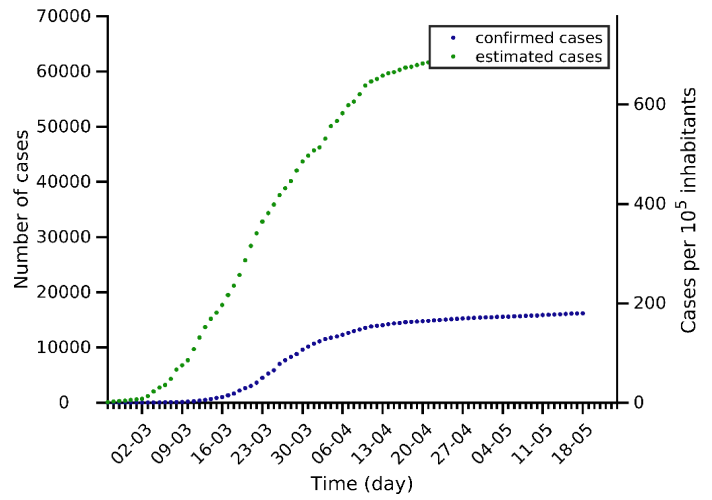
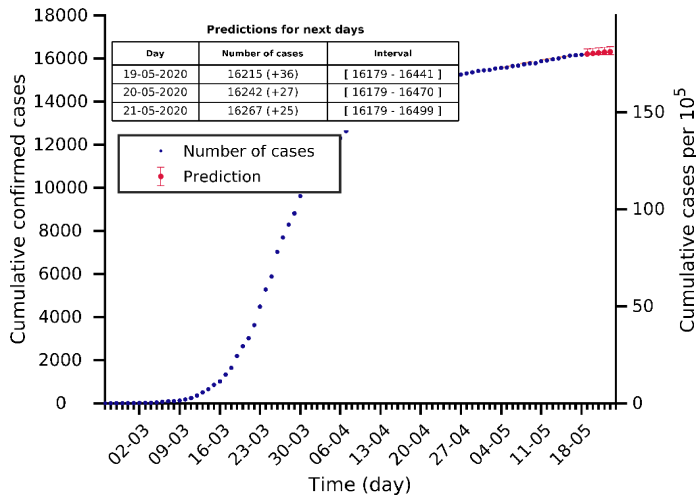
Poland 18-05-2020. Population: 37.8M. Current cumulated incidence: 50/10⁵



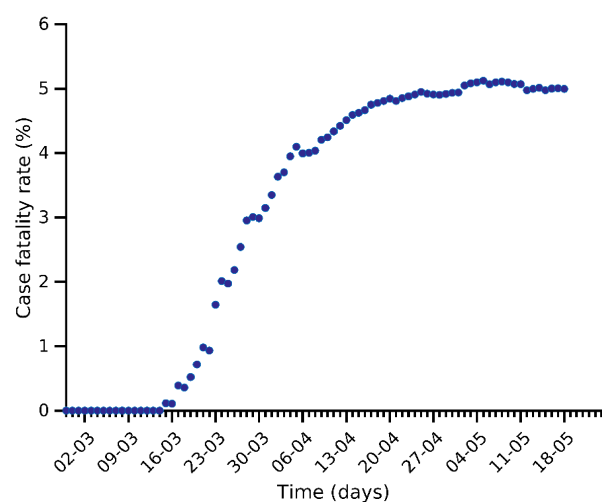
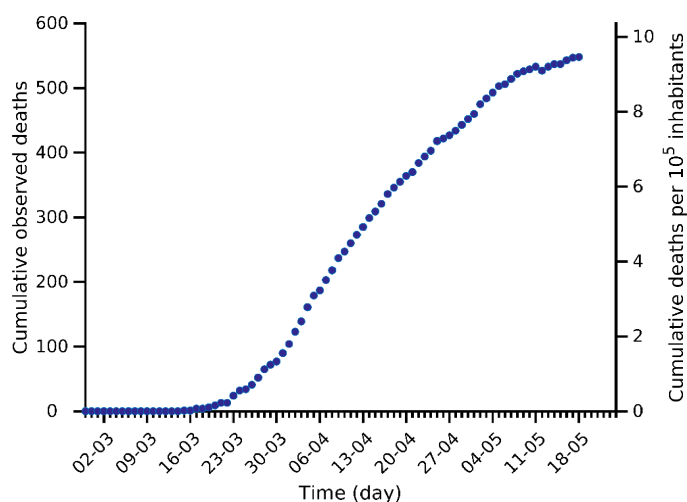
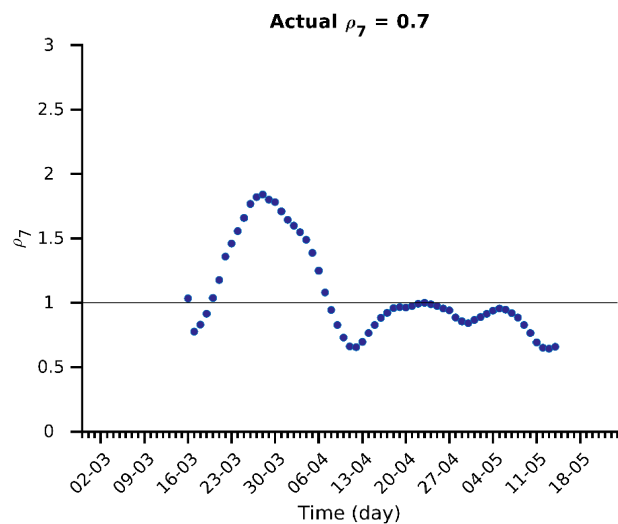
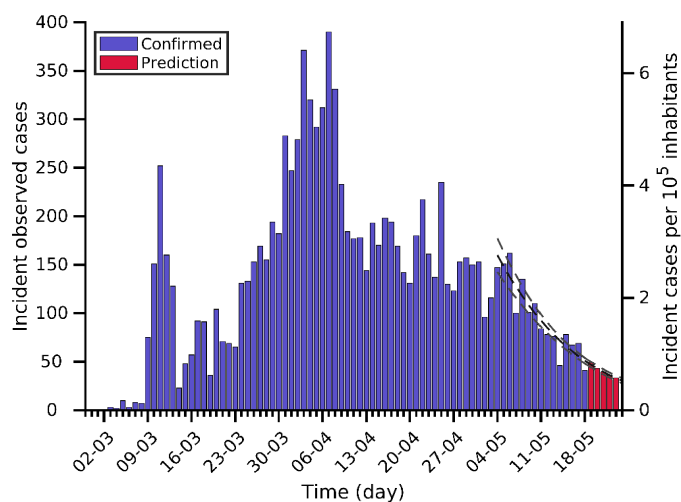
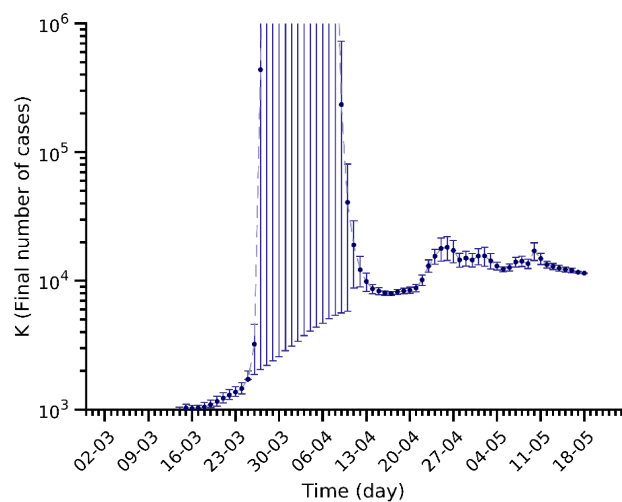
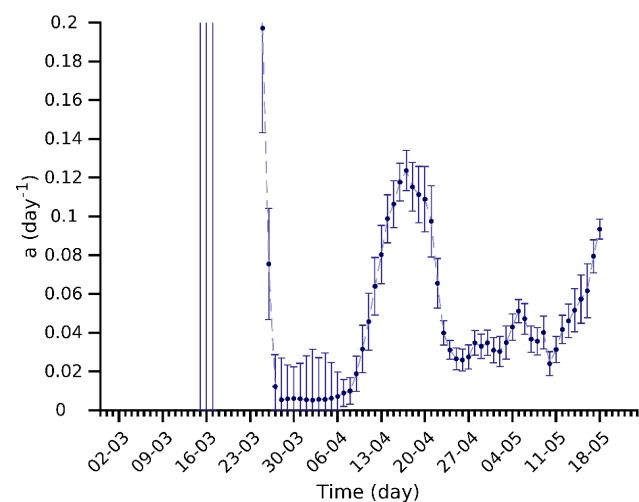
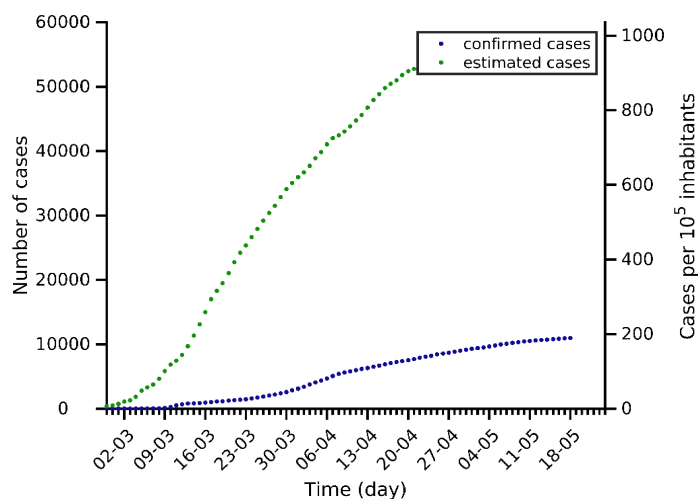
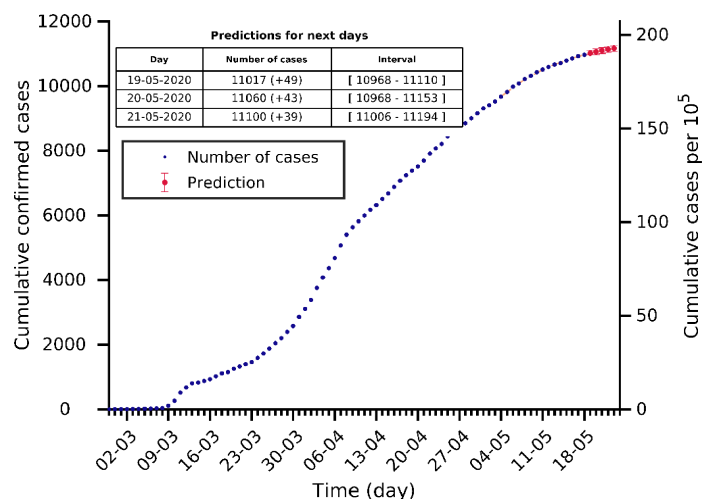
Romania 18-05-2020. Population: 19.2M. Current cumulated incidence: 89/10⁵



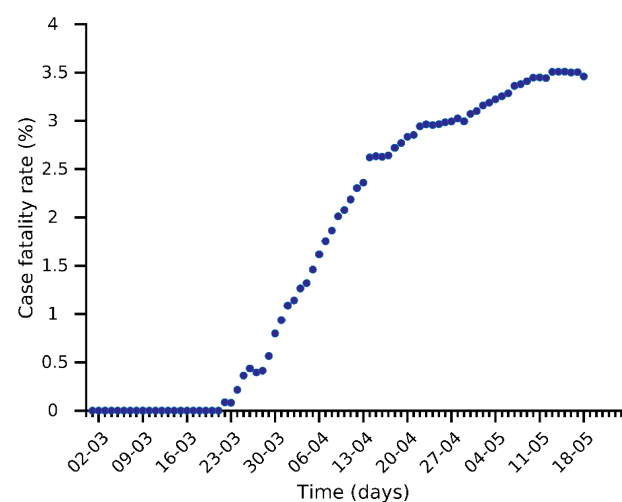
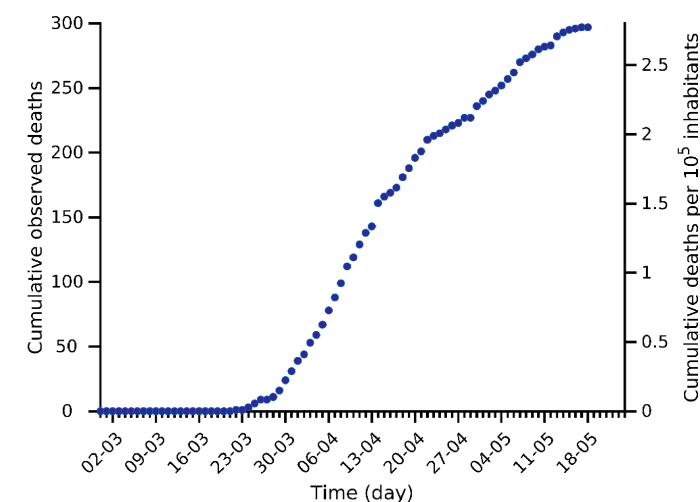
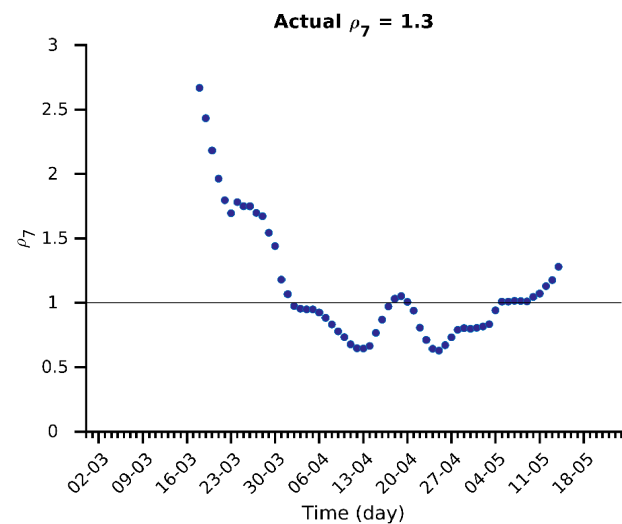
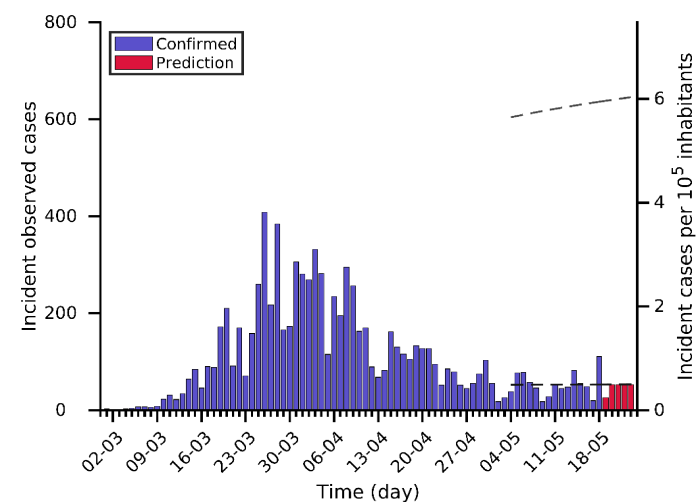
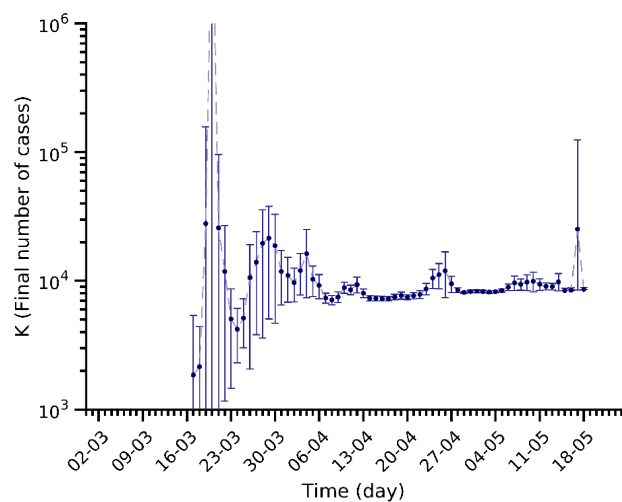
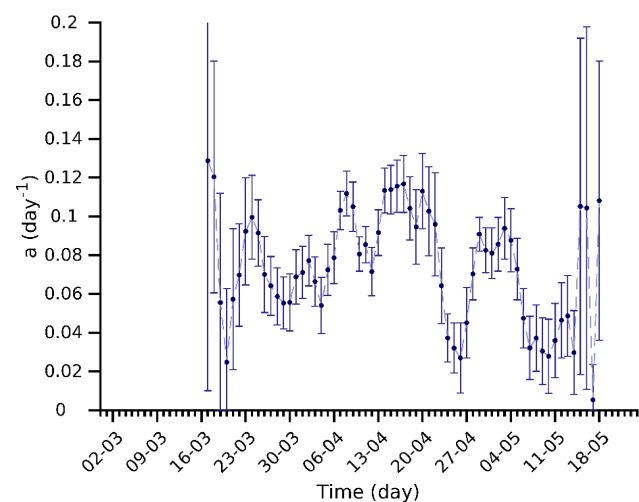
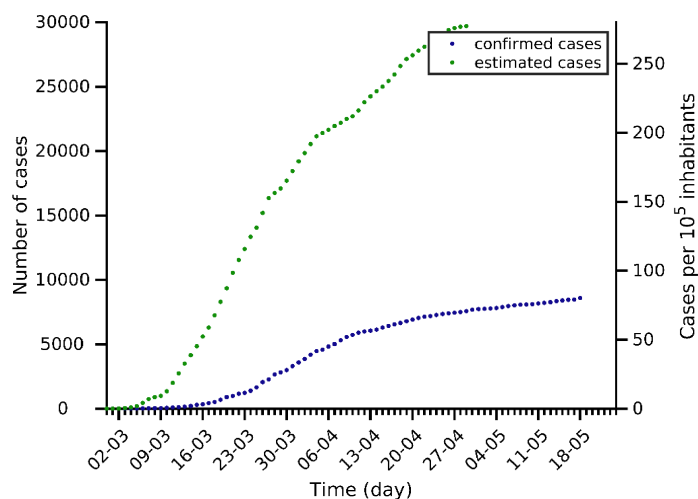
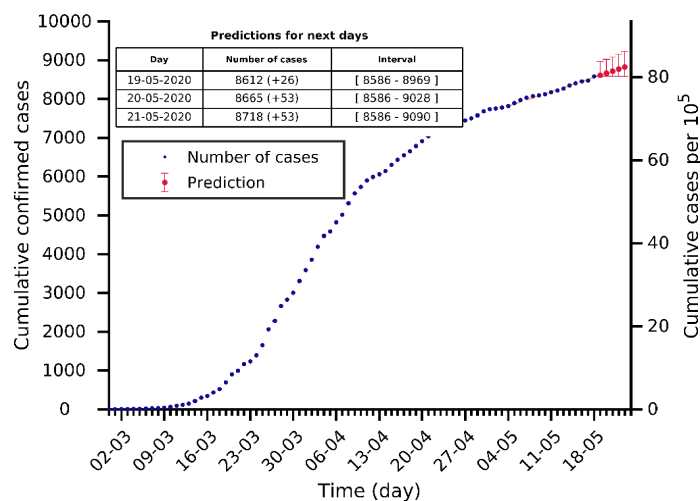
Austria 18-05-2020. Population: 9.0M. Current cumulated incidence: 180/10⁵



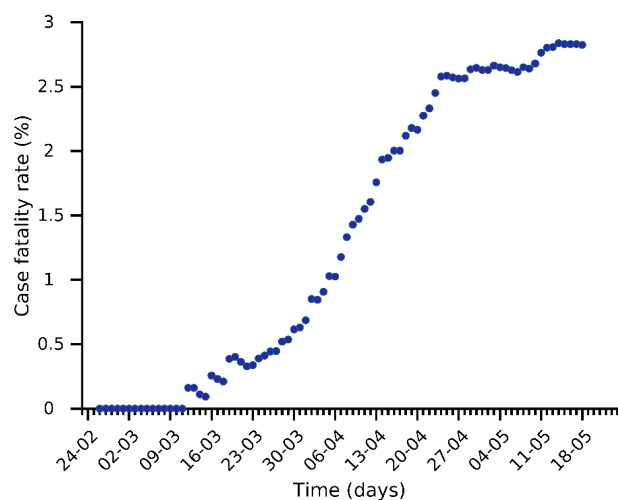
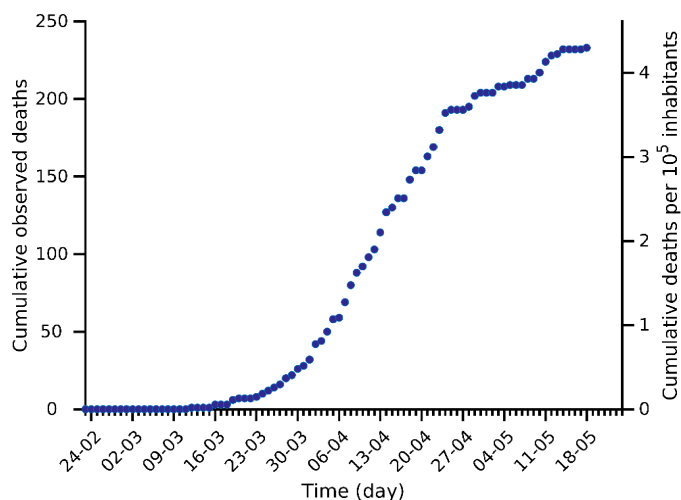
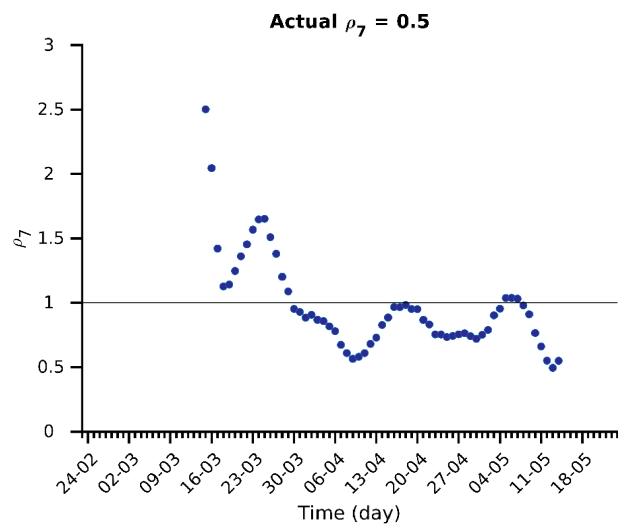
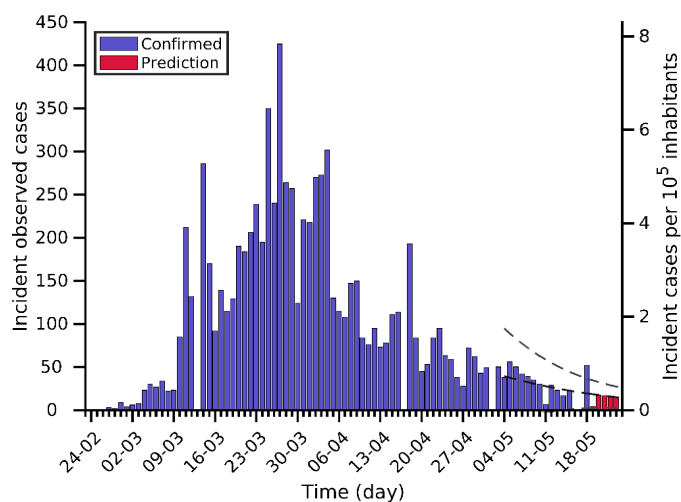
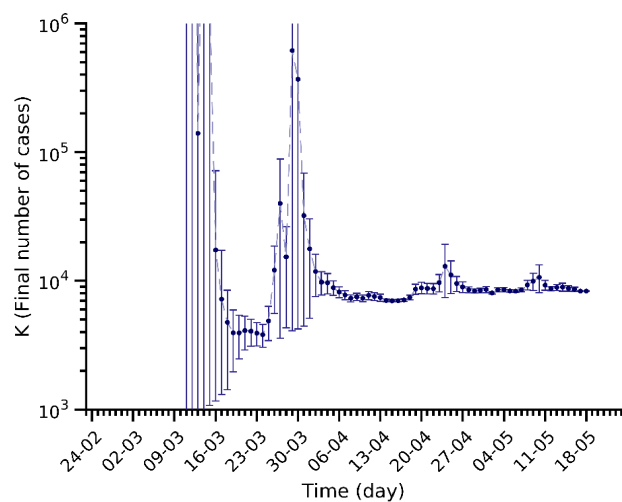
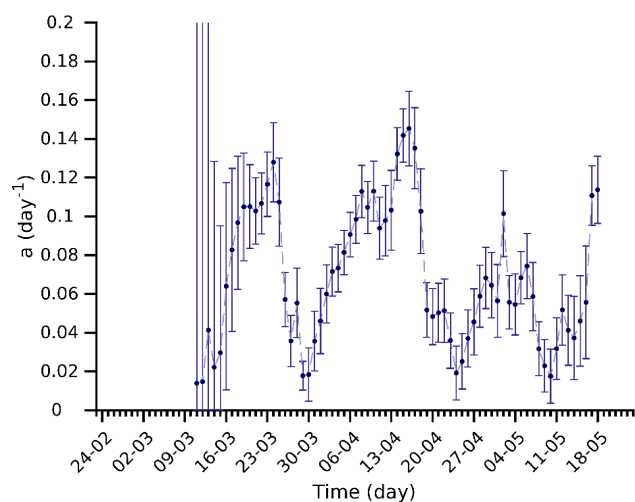
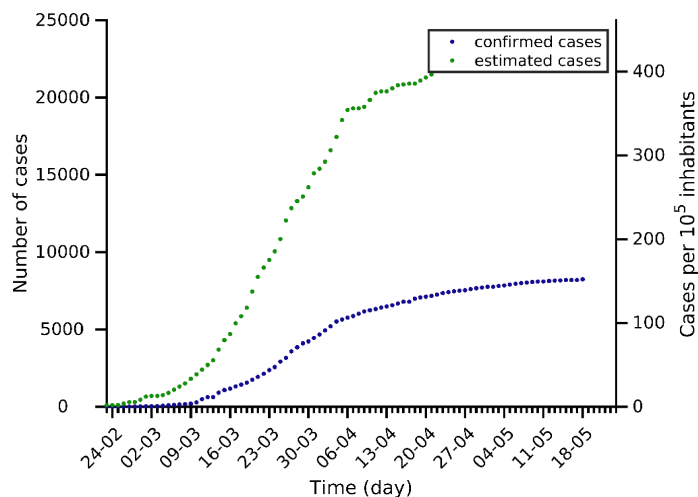
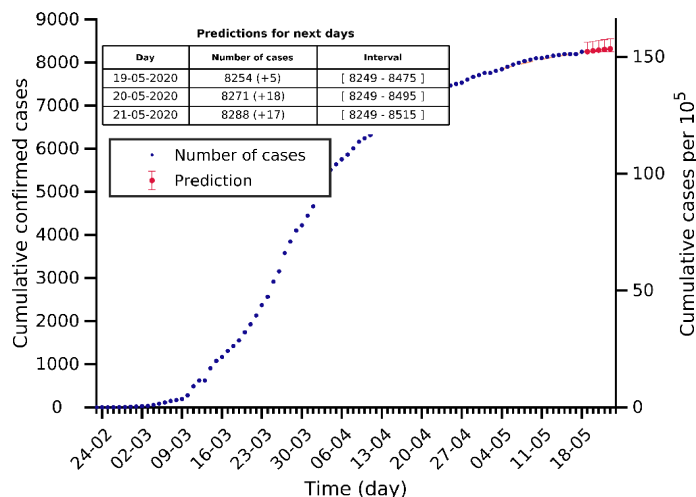
Denmark 18-05-2020. Population: 5.8M. Current cumulated incidence: 189/10⁵



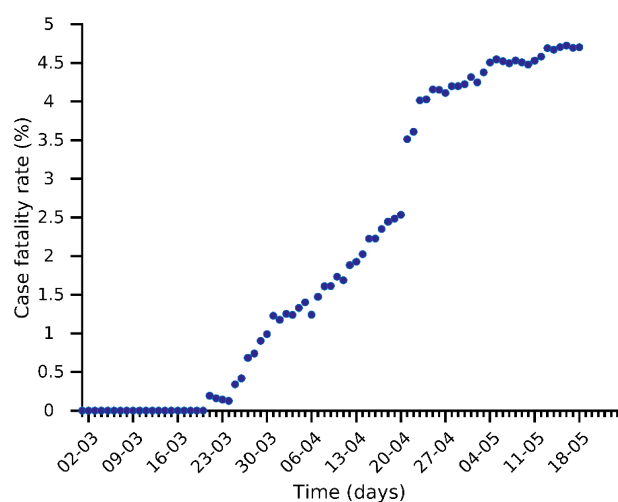
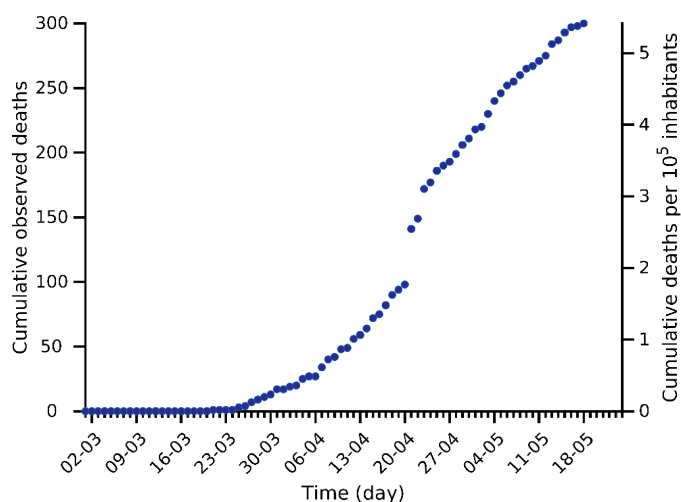
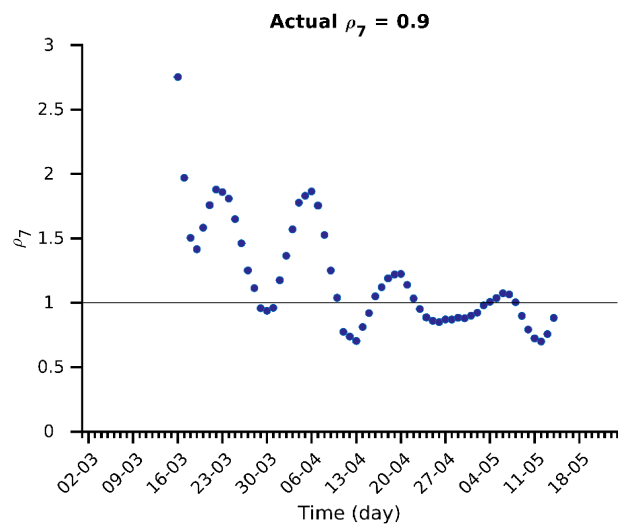
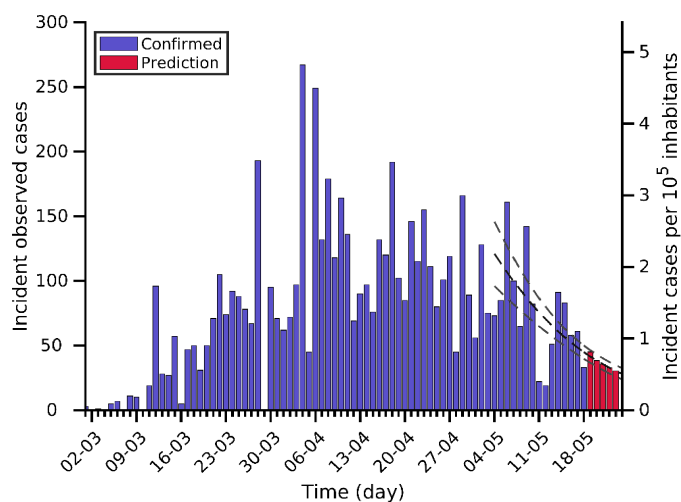
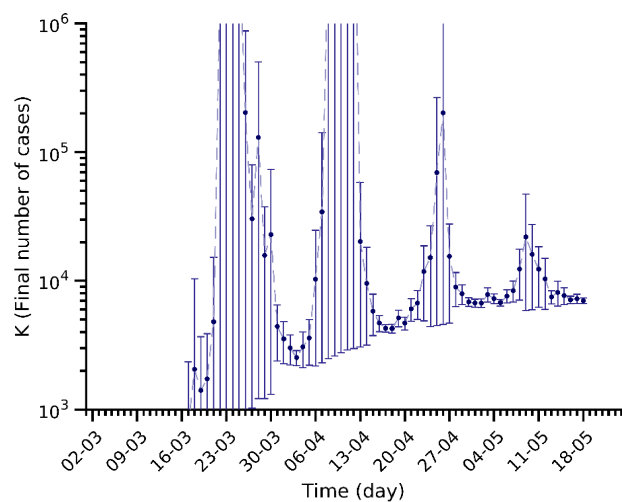
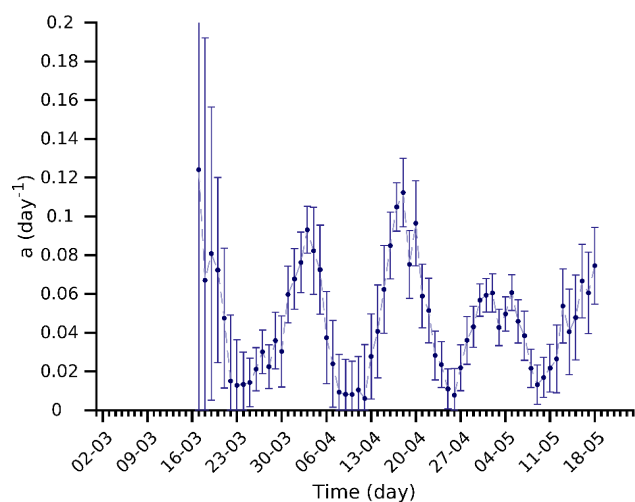
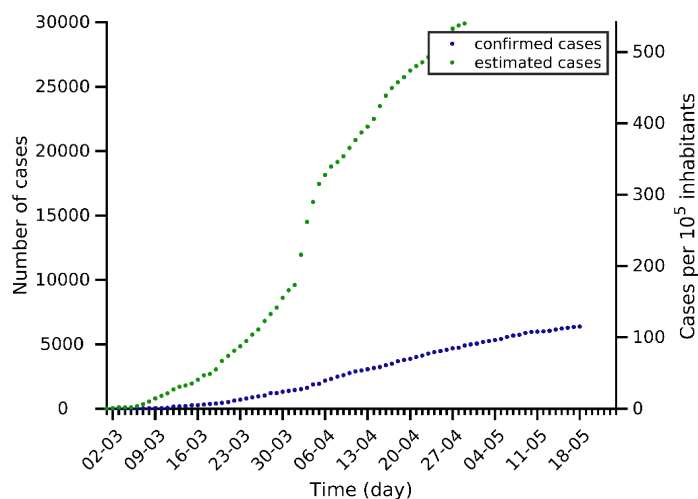
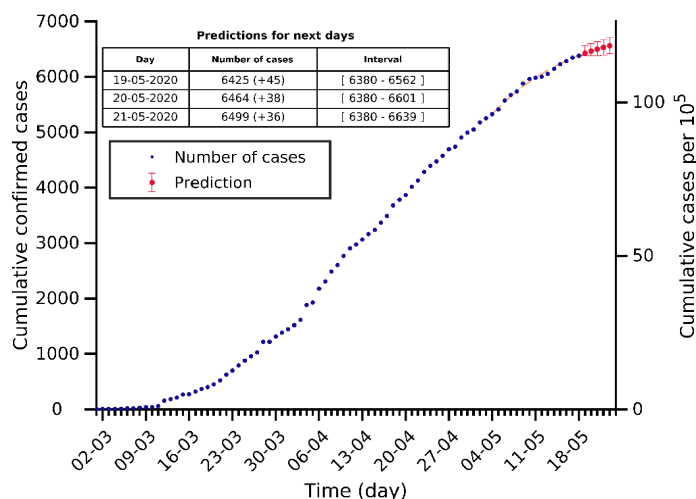
Czech Rep 18-05-2020. Population: 10.7M. Current cumulated incidence: 80/10⁵



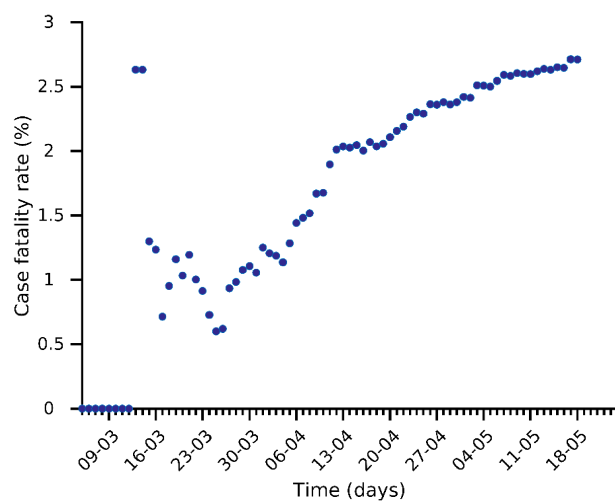
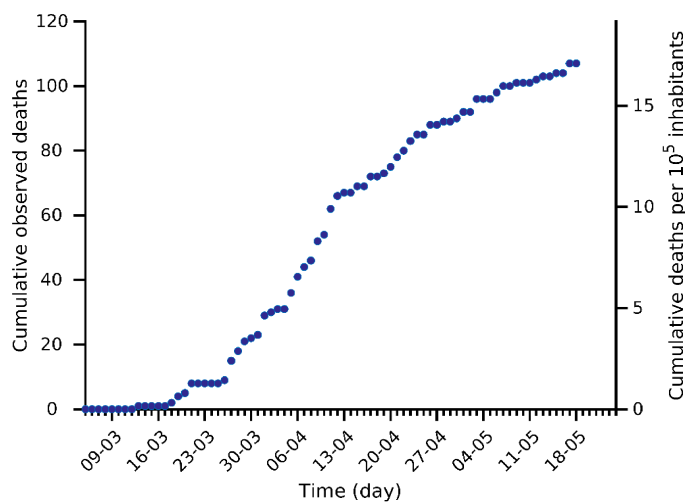
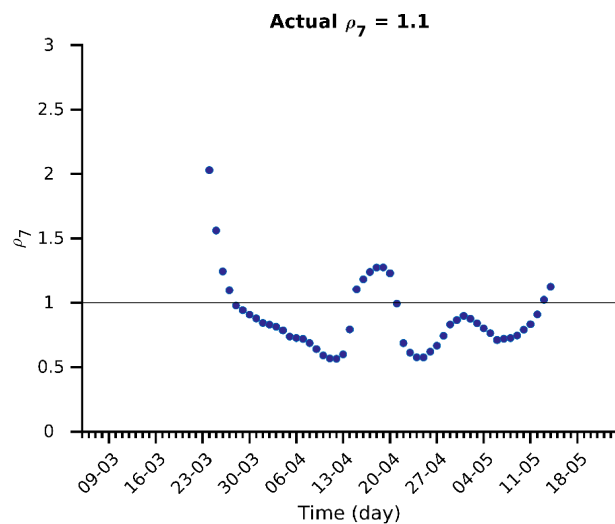
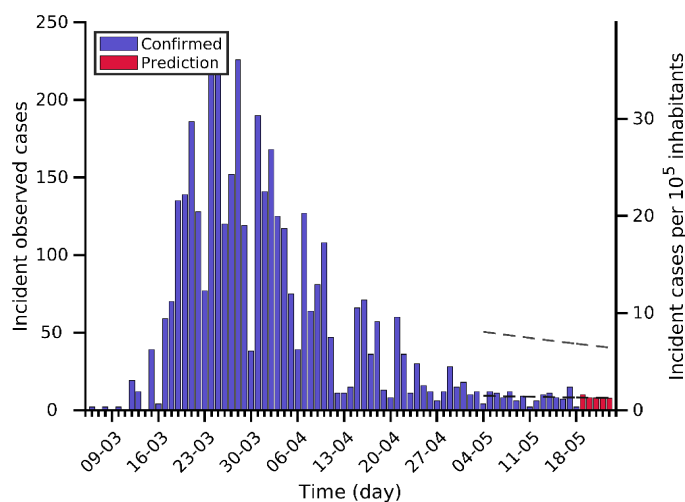
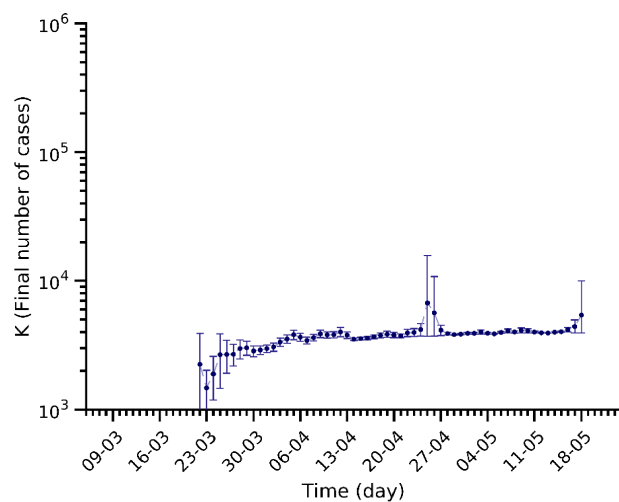
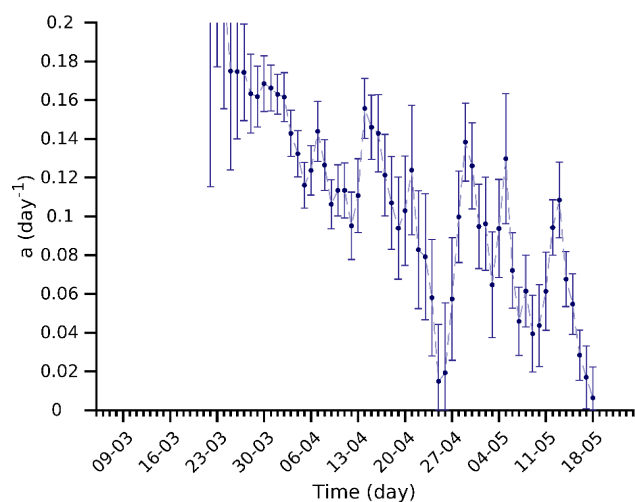
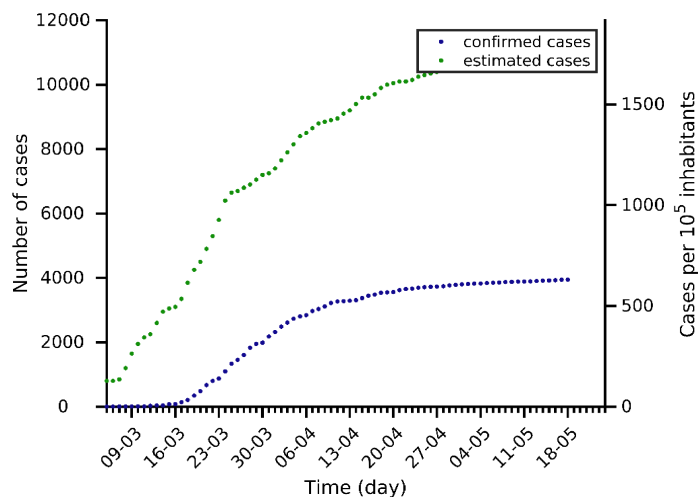
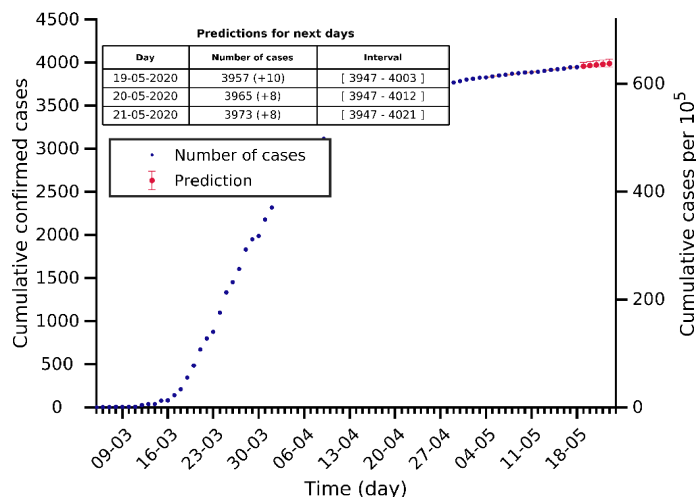
Norway 18-05-2020. Population: 5.4M. Current cumulated incidence: 152/10⁵



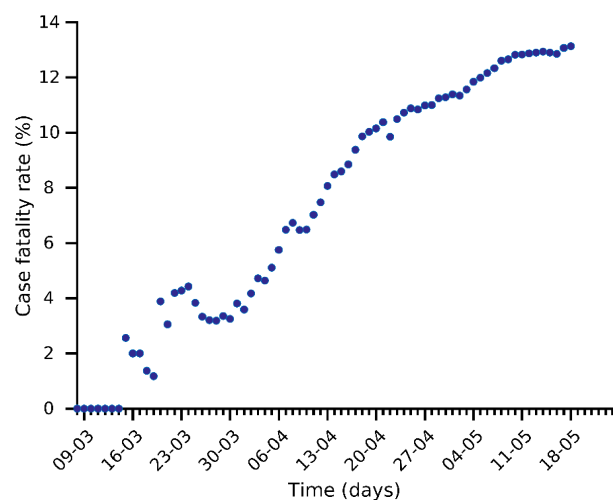
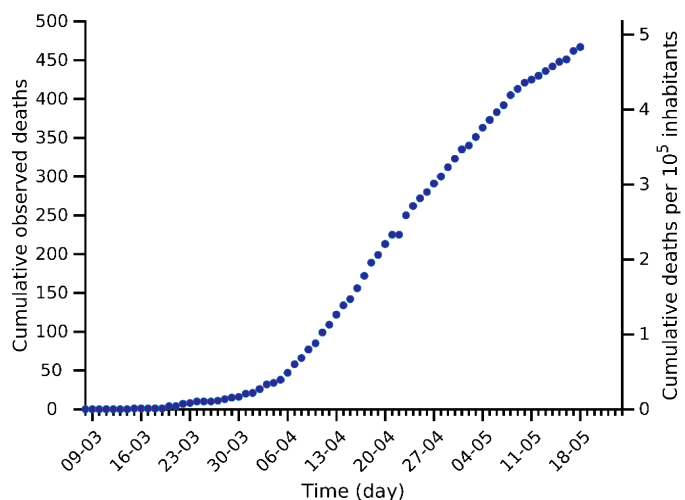
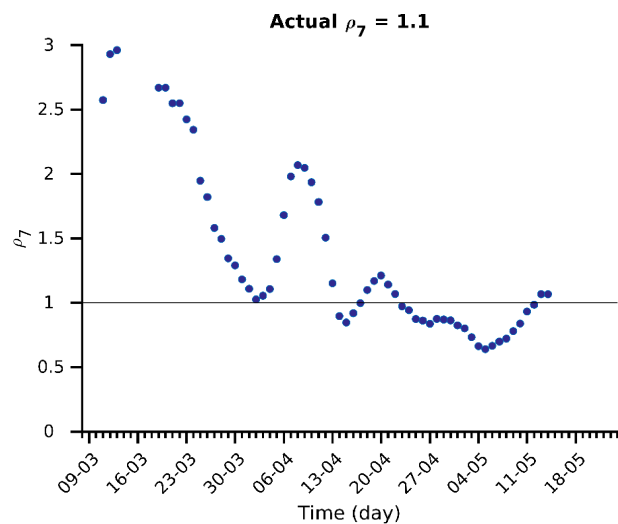
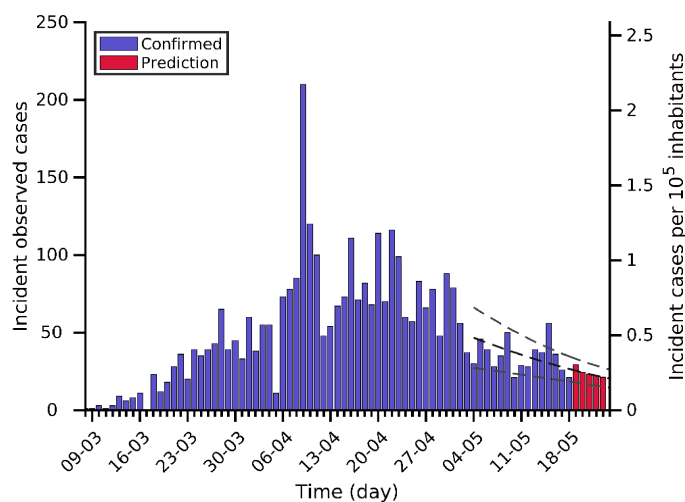
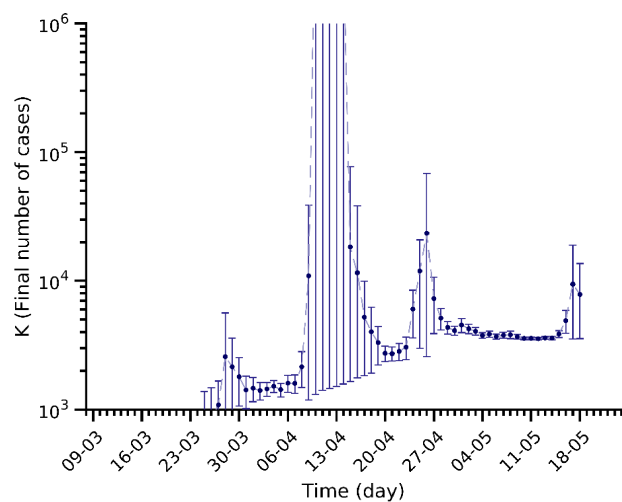
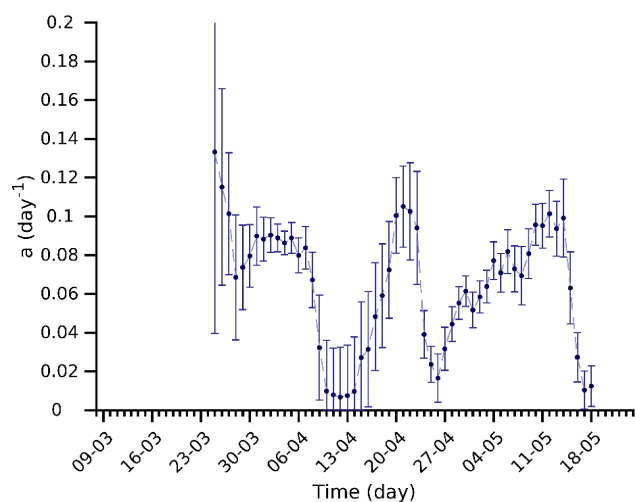
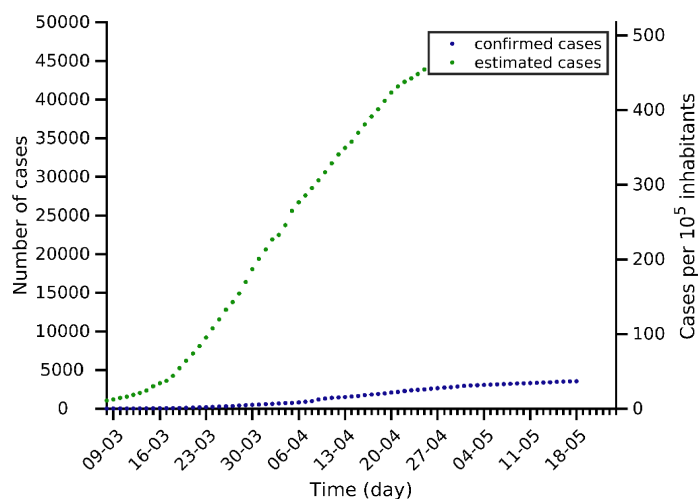
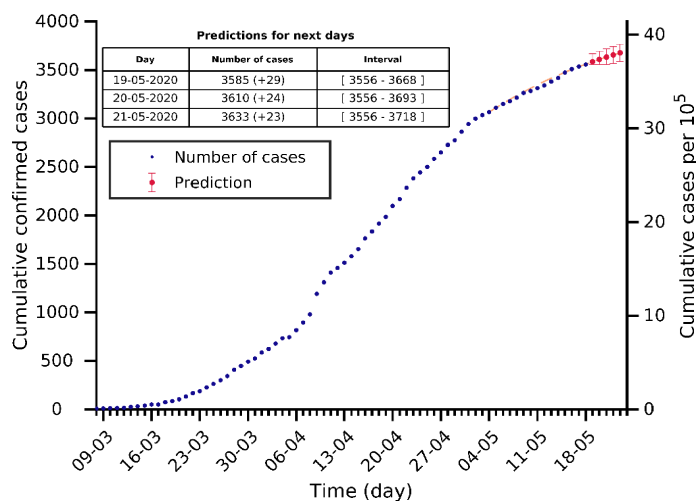
Finland 18-05-2020. Population: 5.5M. Current cumulated incidence: 115/10⁵



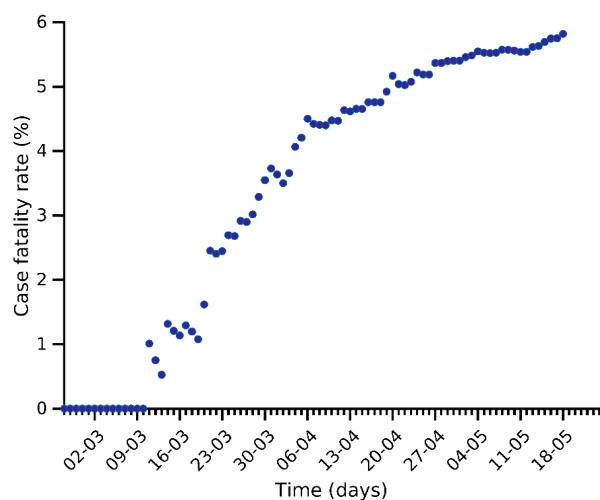
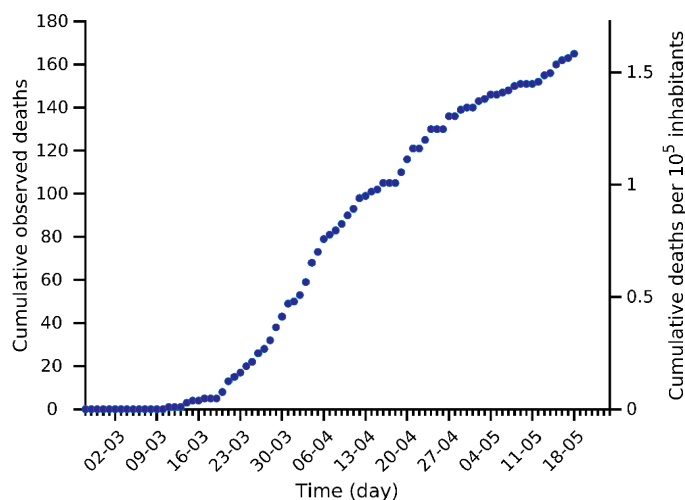
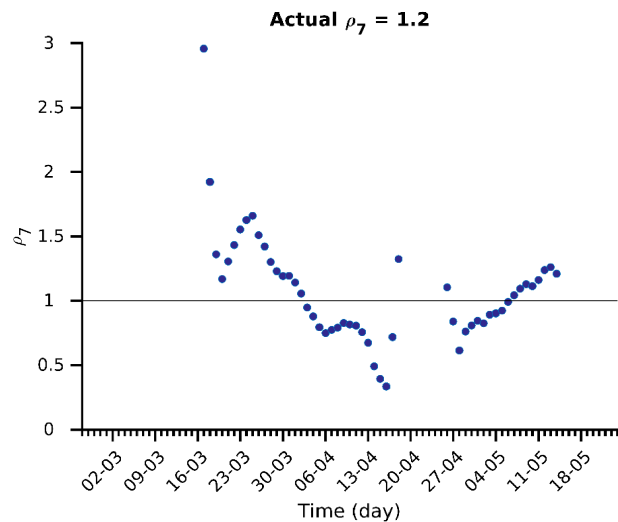
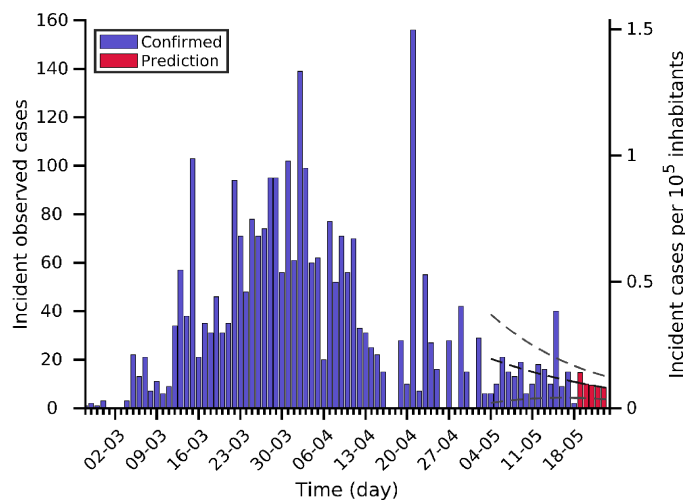
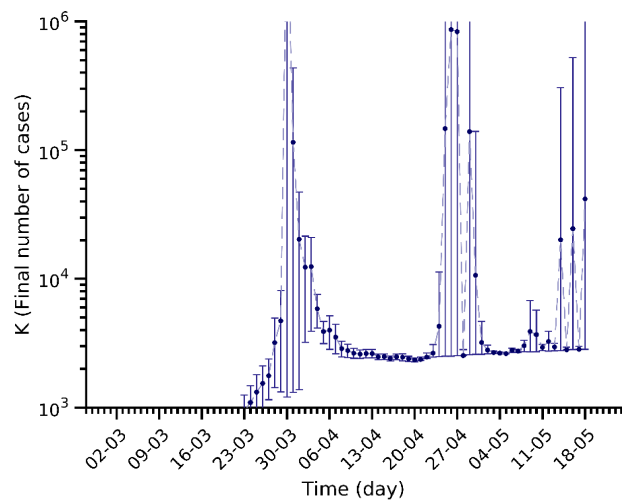
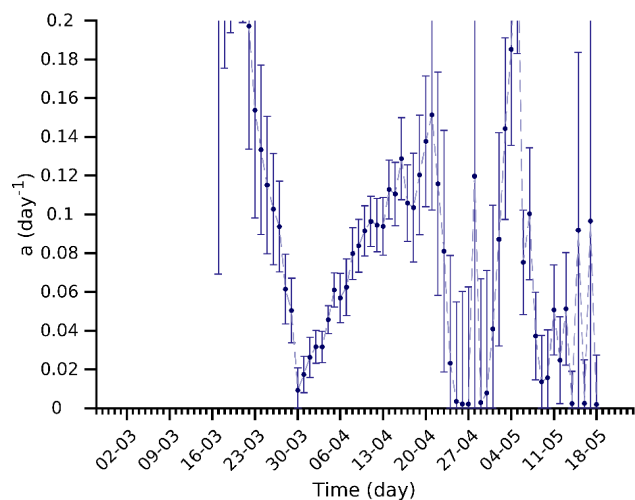
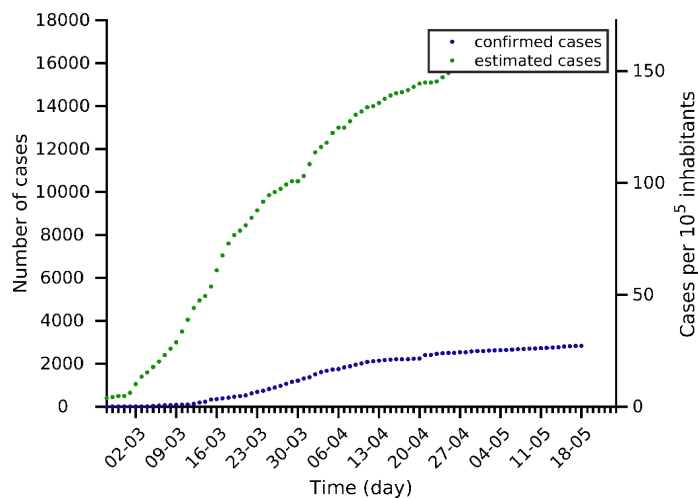
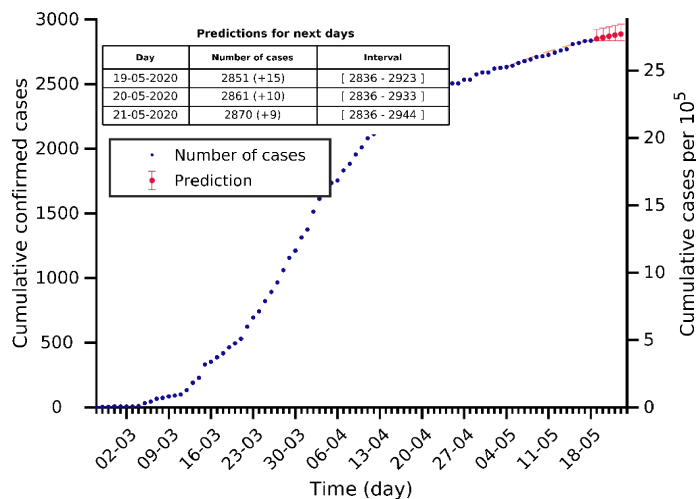
Luxembourg 18-05-2020. Population: 0.6M. Current cumulated incidence: 631/10⁵



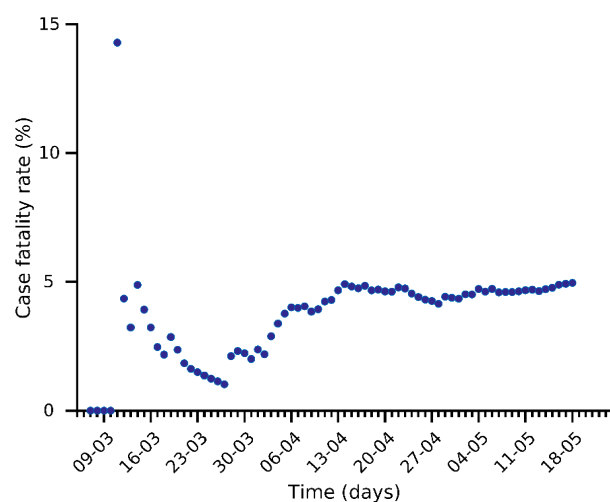
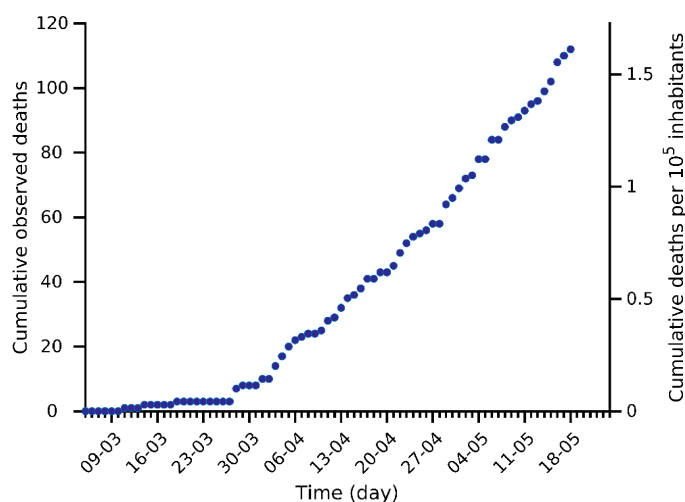
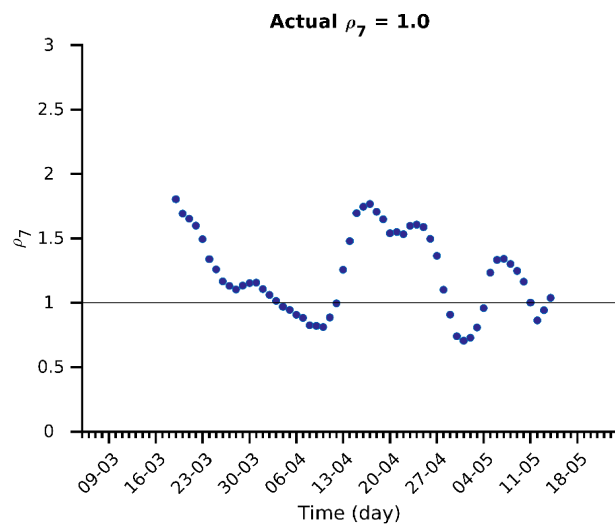
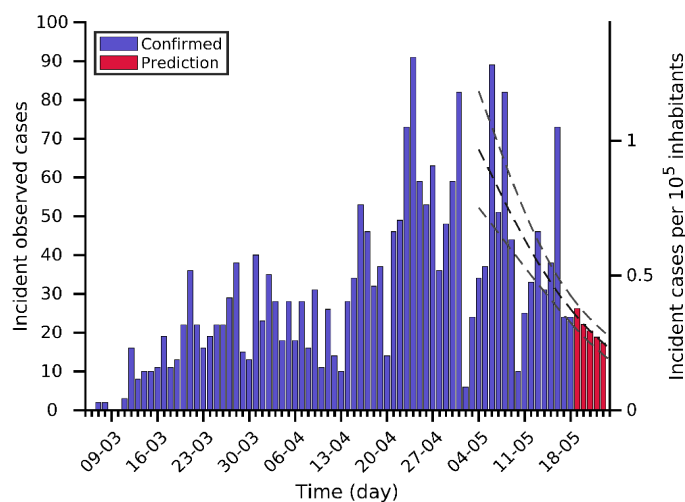
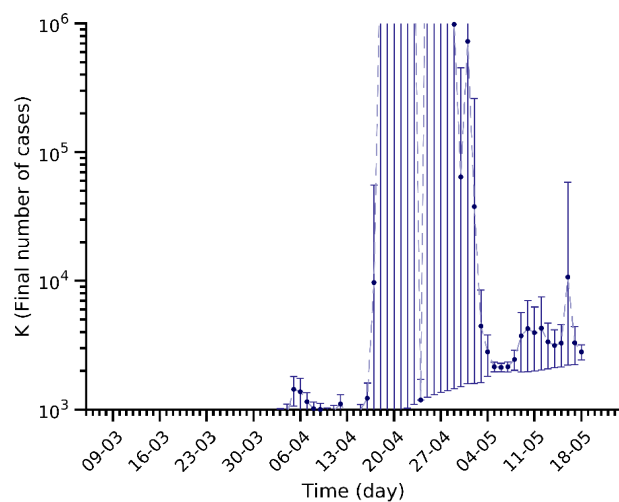
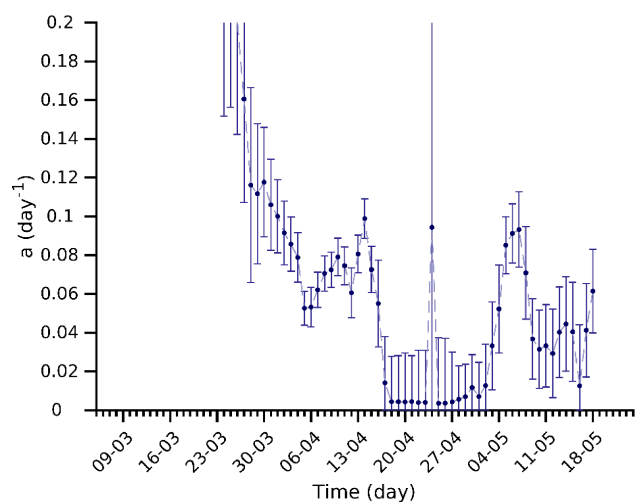
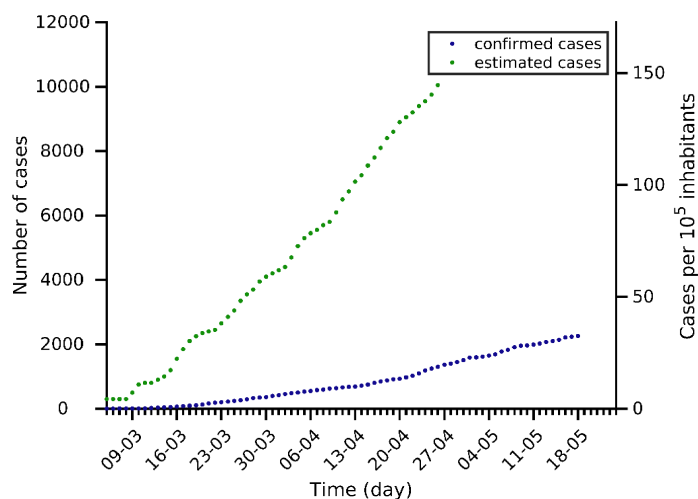
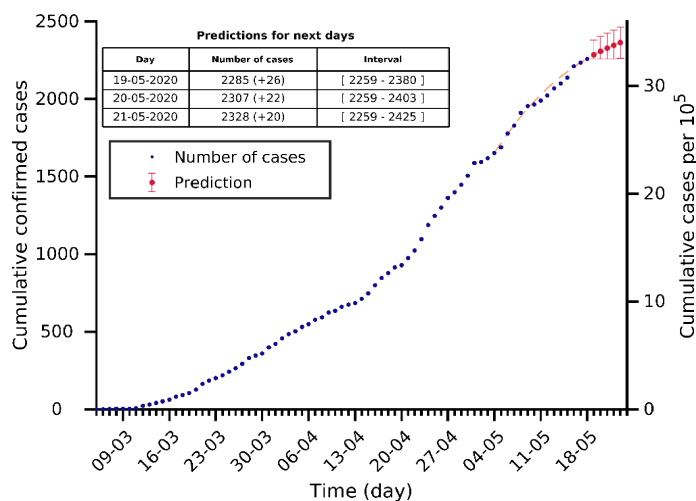
Hungary 18-05-2020. Population: 9.7M. Current cumulated incidence: 37/10⁵



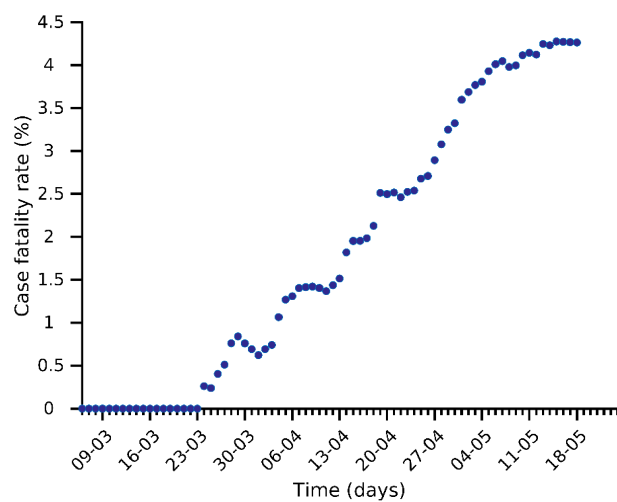
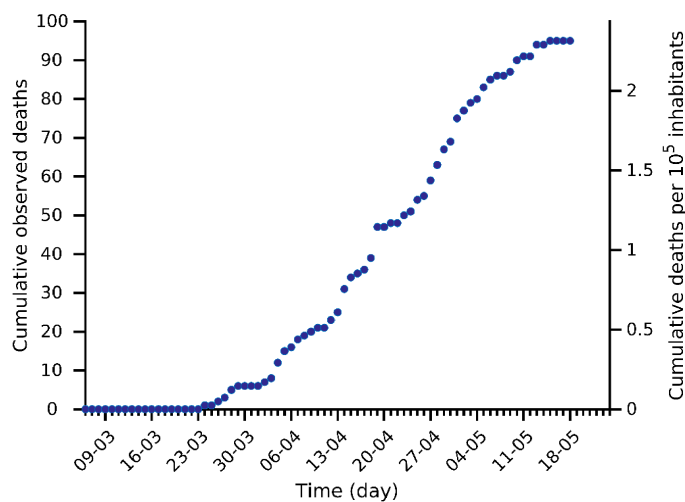
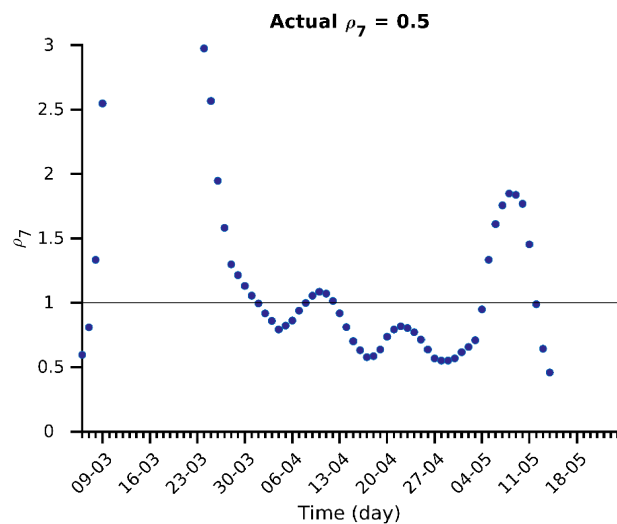
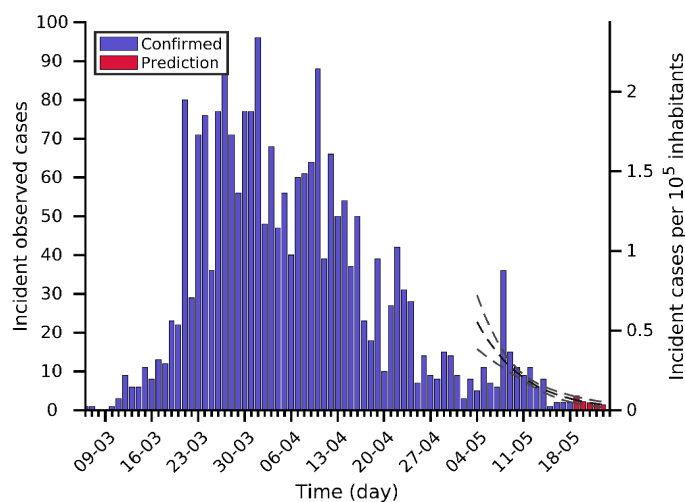
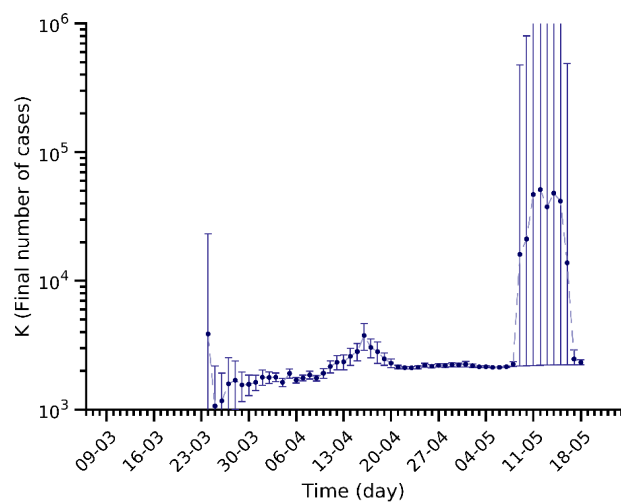
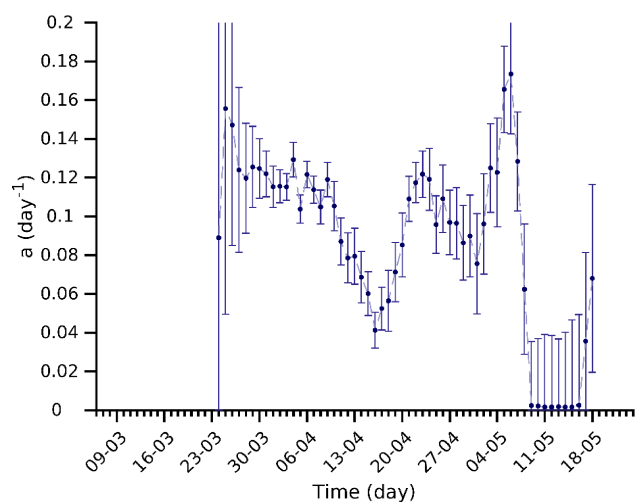
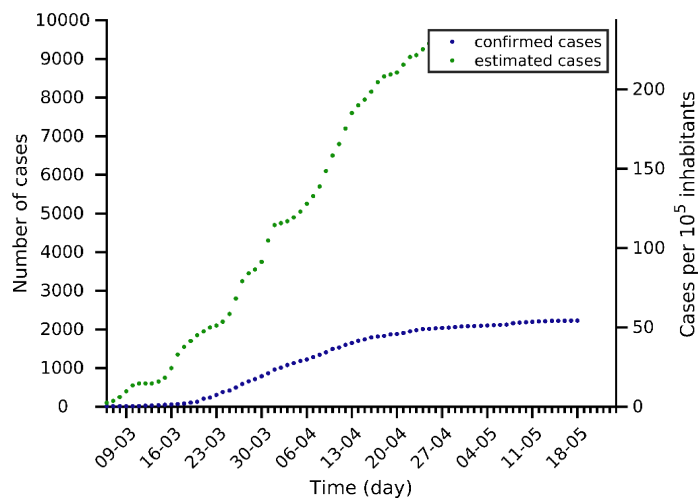
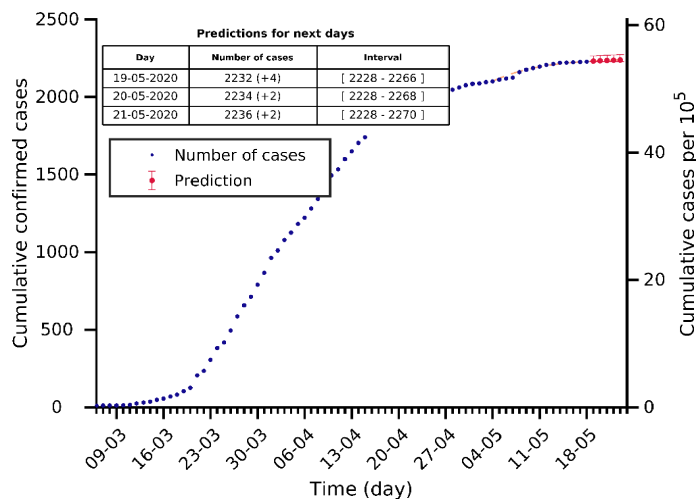
Greece 18-05-2020. Population: 10.4M. Current cumulated incidence: 27/10⁵



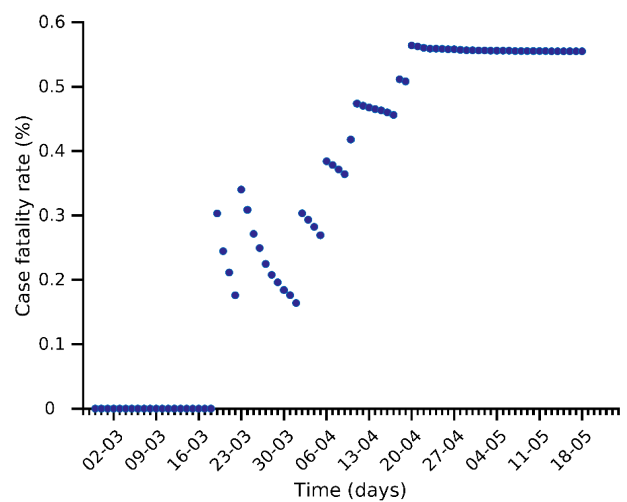
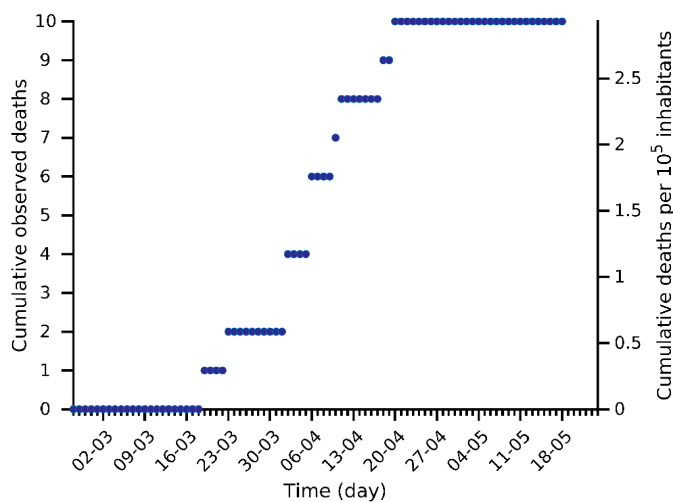
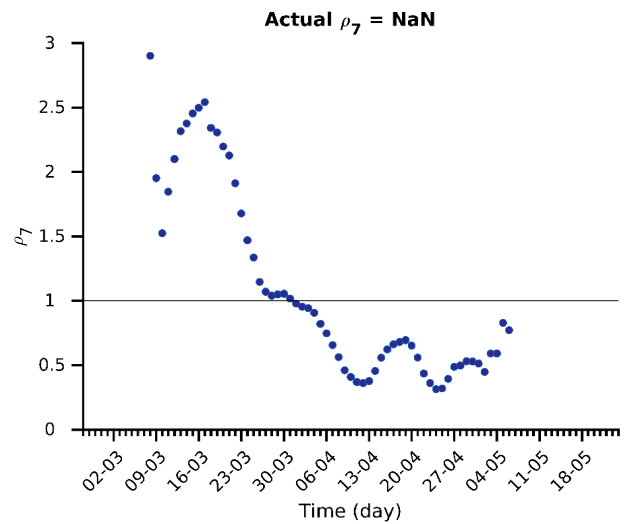
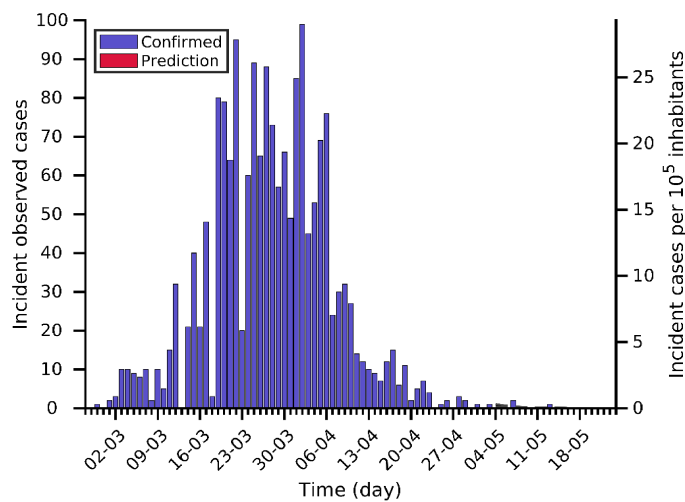
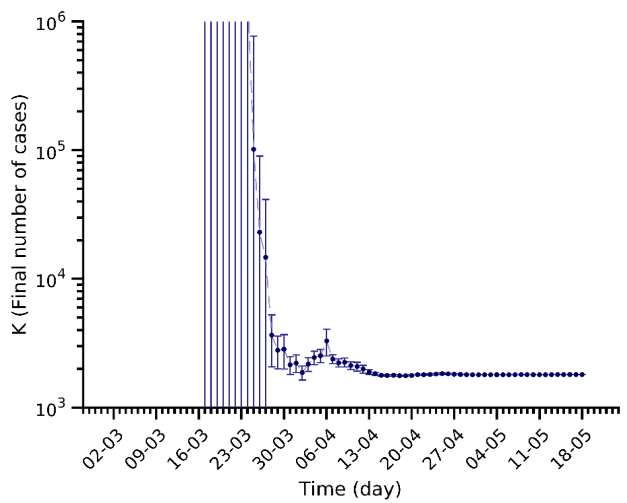
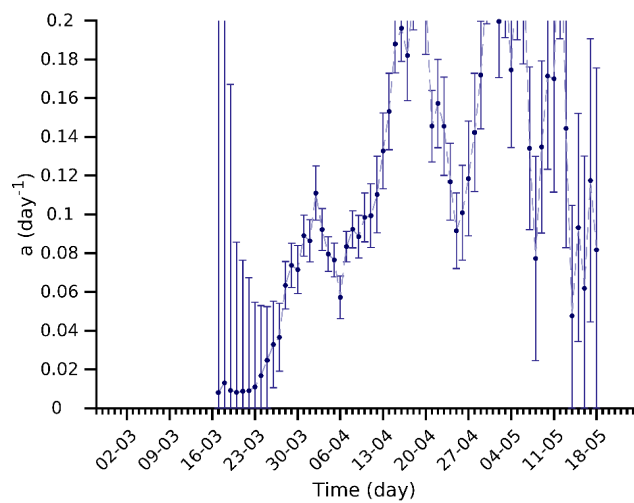
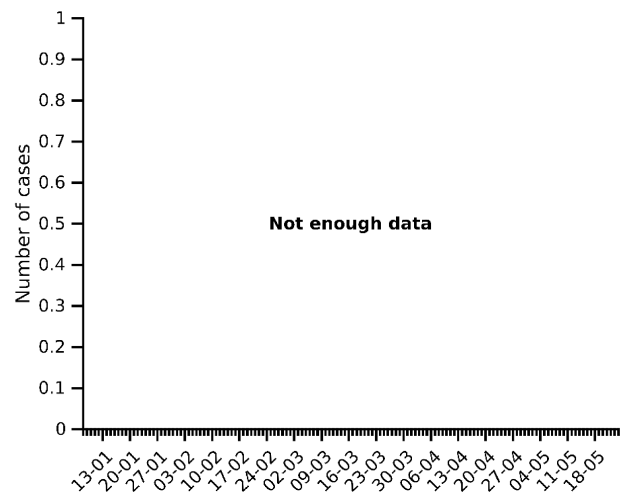
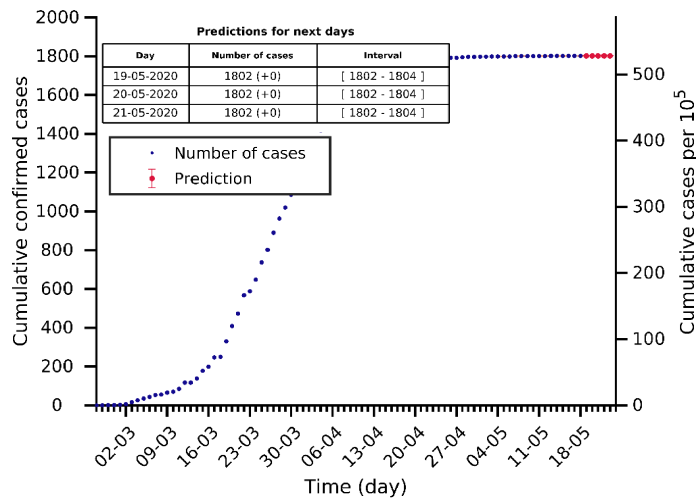
Bulgaria 18-05-2020. Population: 6.9M. Current cumulated incidence: 33/10⁵



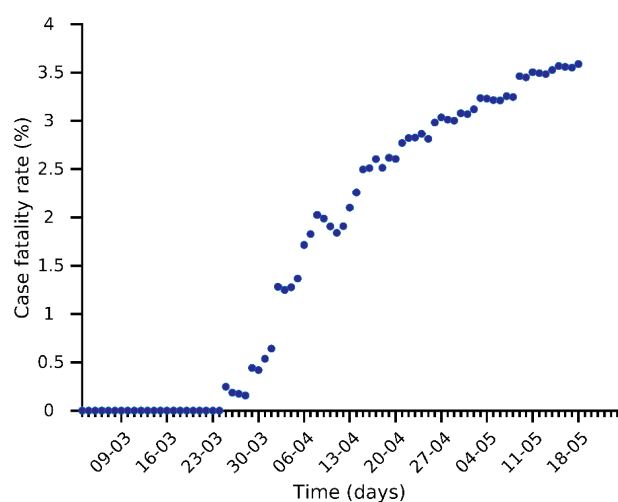
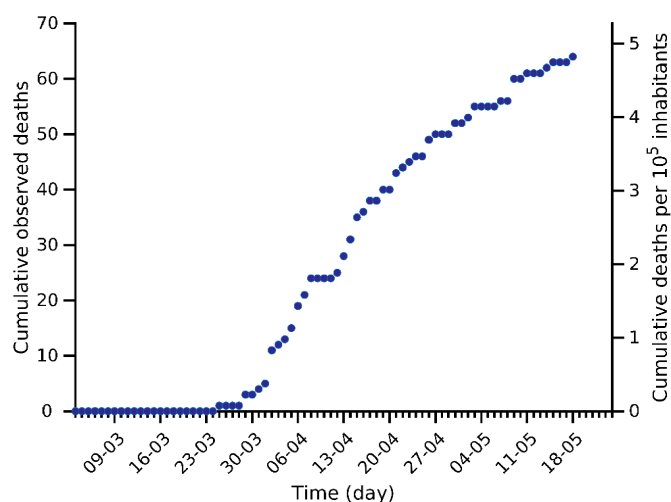
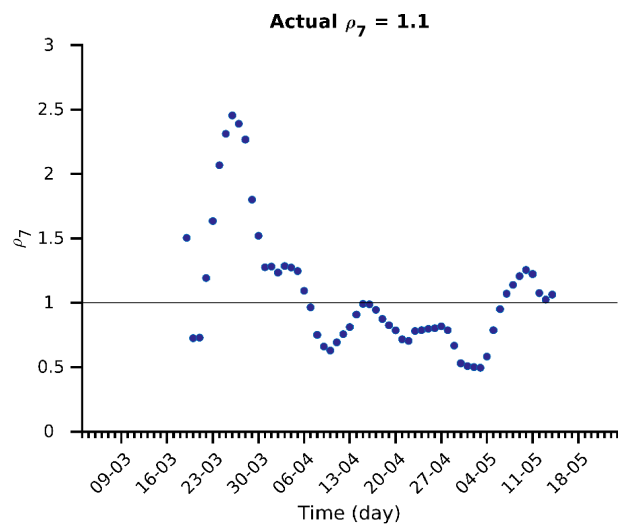
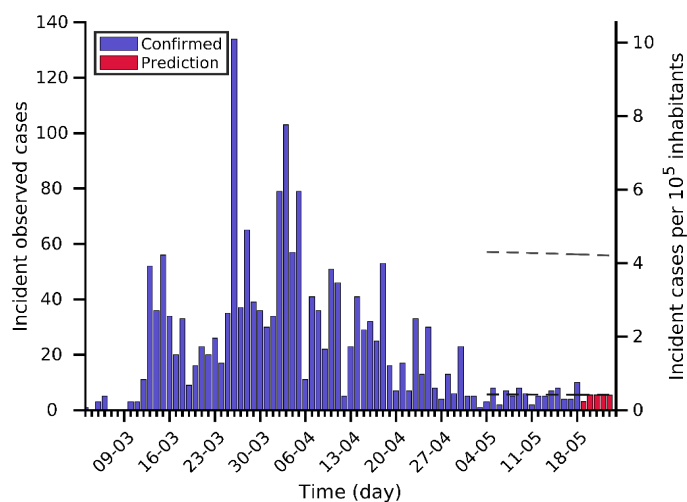
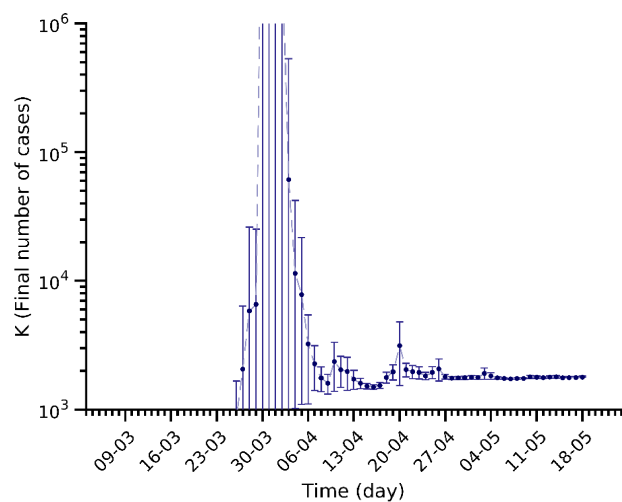
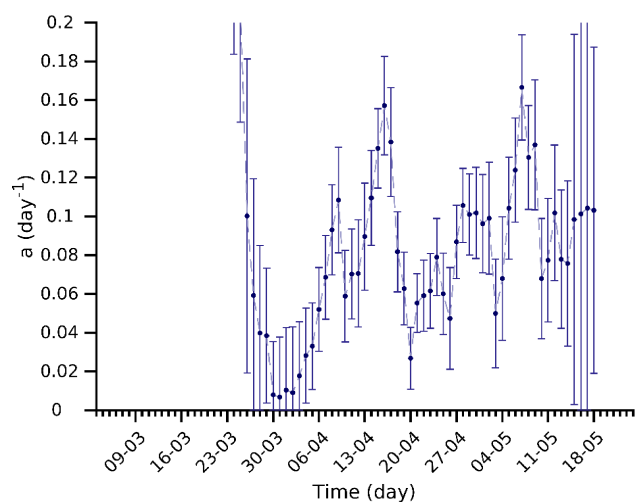
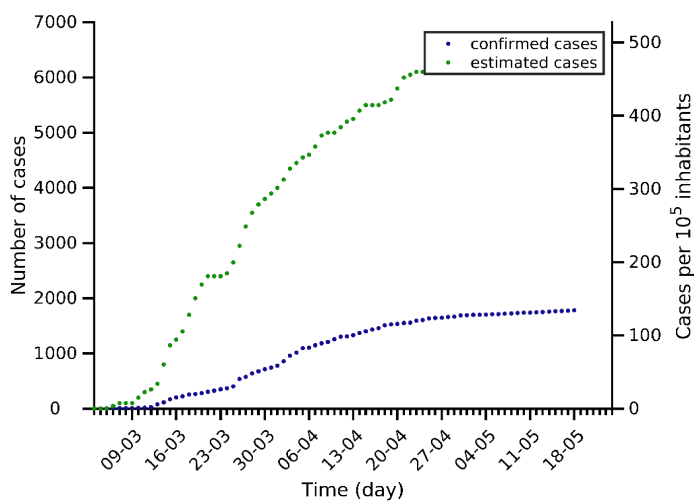
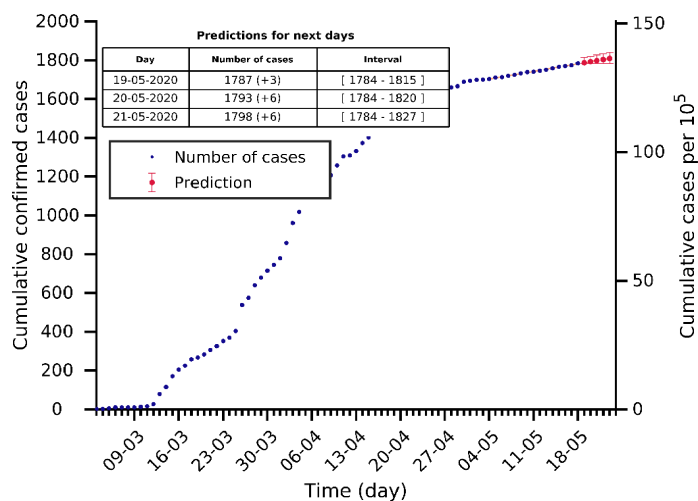
Croatia 18-05-2020. Population: 4.1M. Current cumulated incidence: 54/10⁵



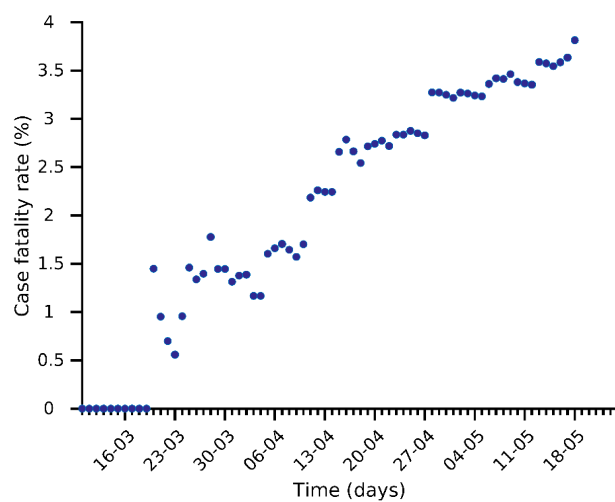
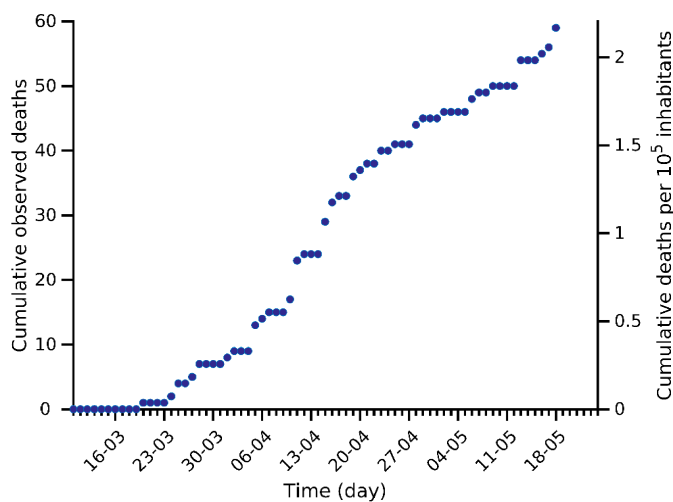
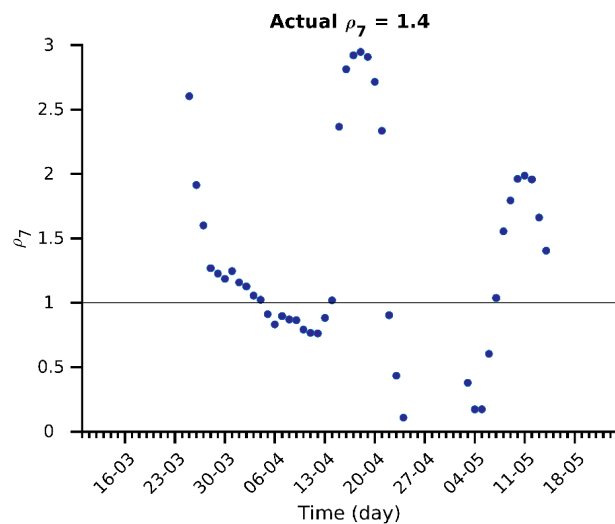
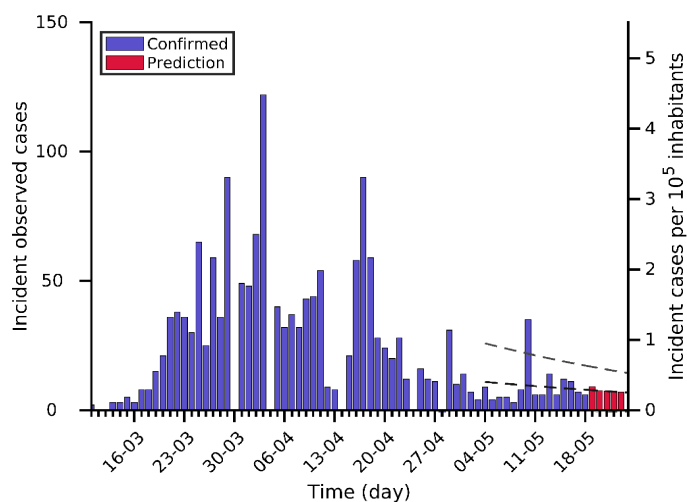
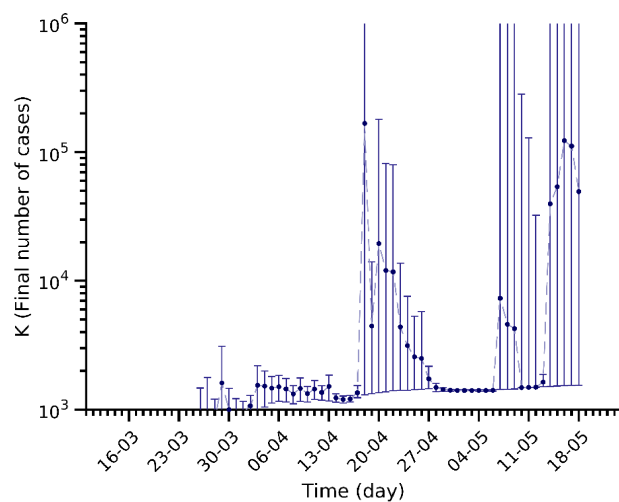
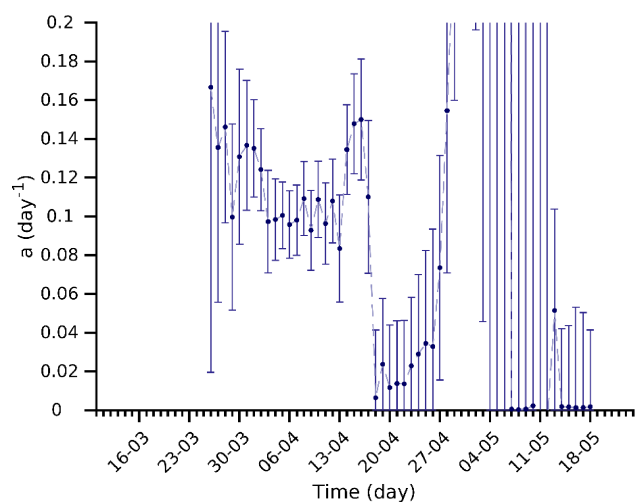
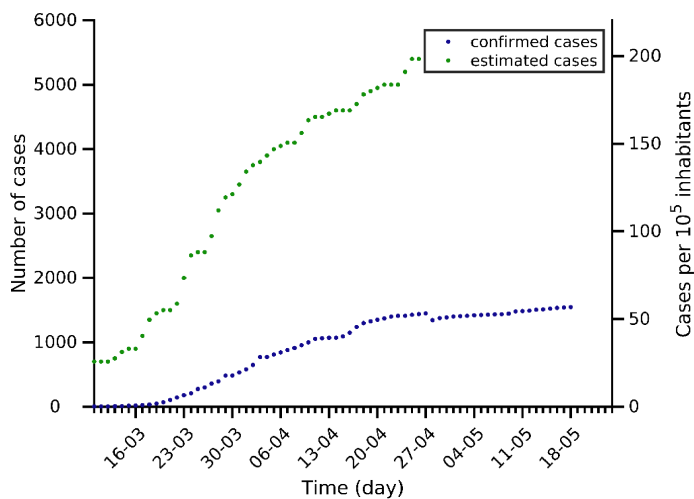
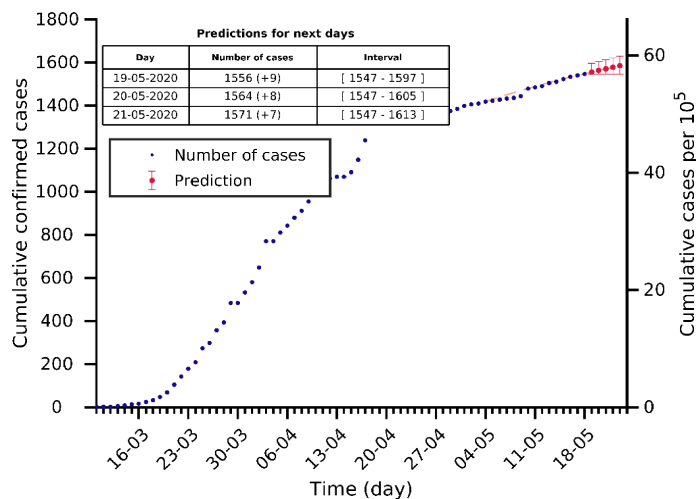
Iceland 18-05-2020. Population: 0.3M. Current cumulated incidence: 528/10⁵



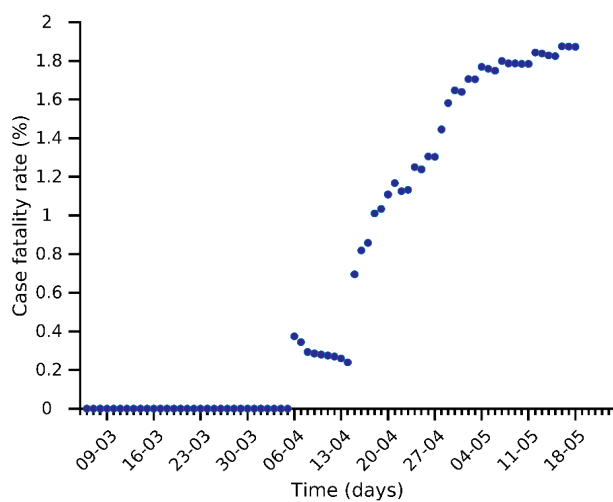
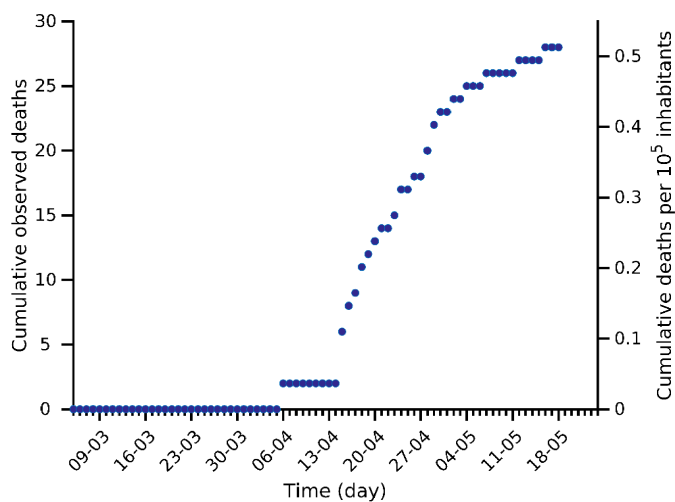
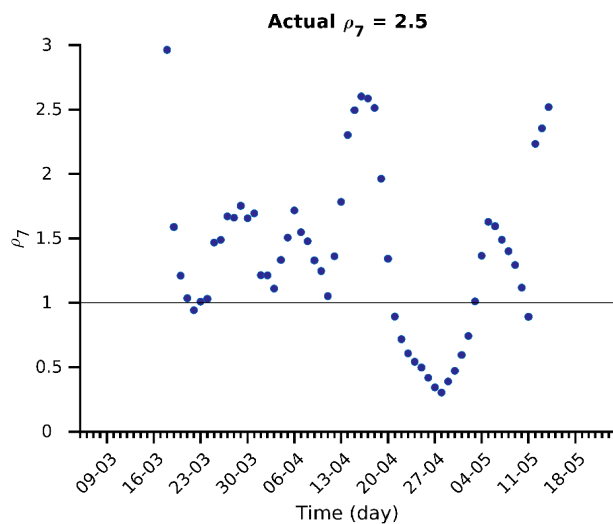
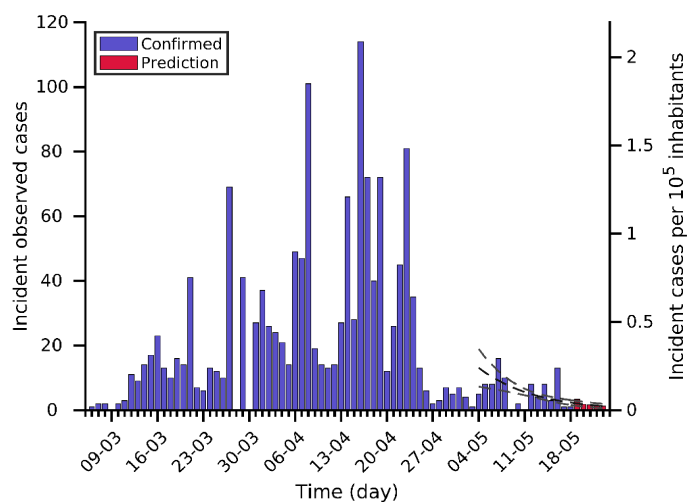
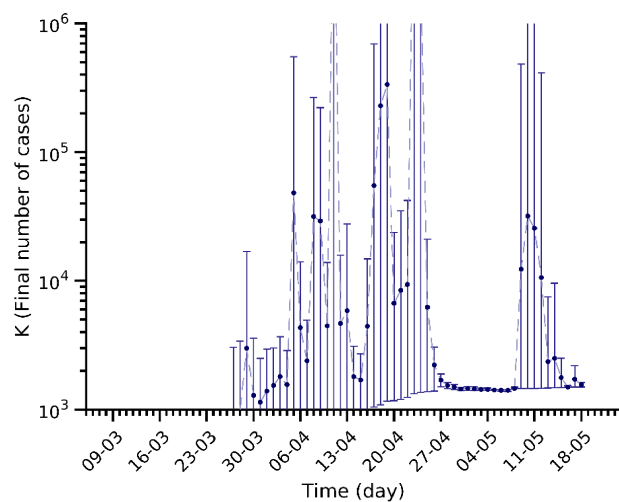
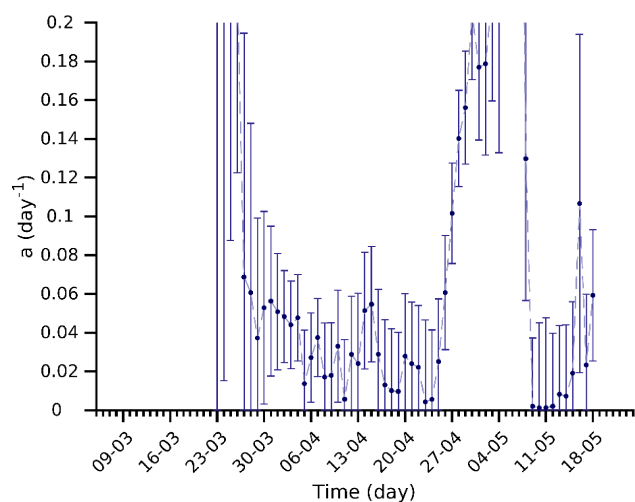
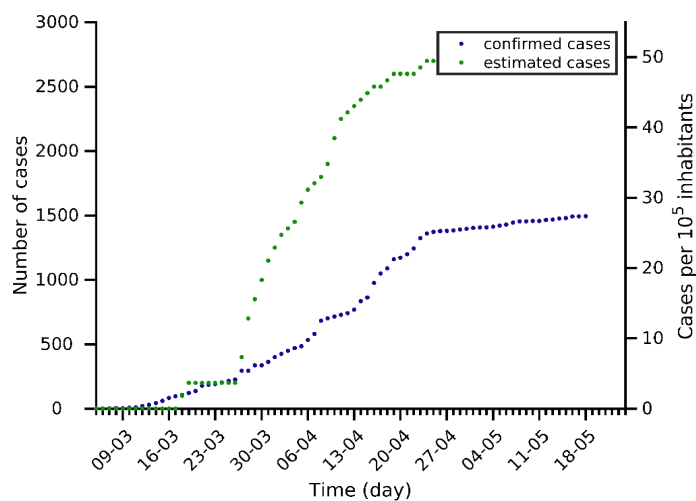
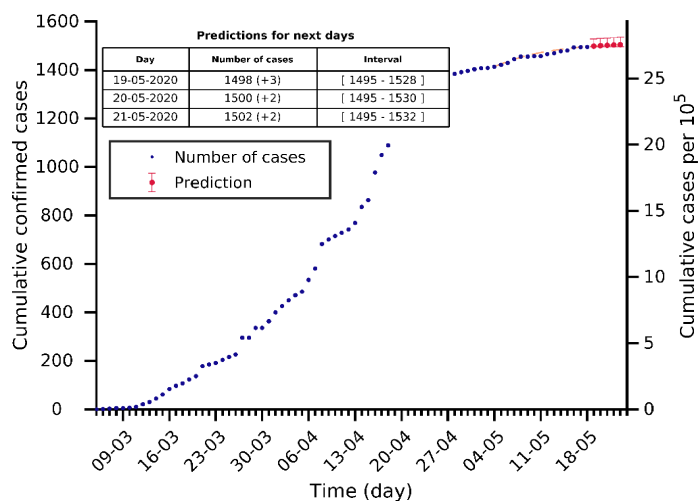
Estonia 18-05-2020. Population: 1.3M. Current cumulated incidence: 134/10⁵



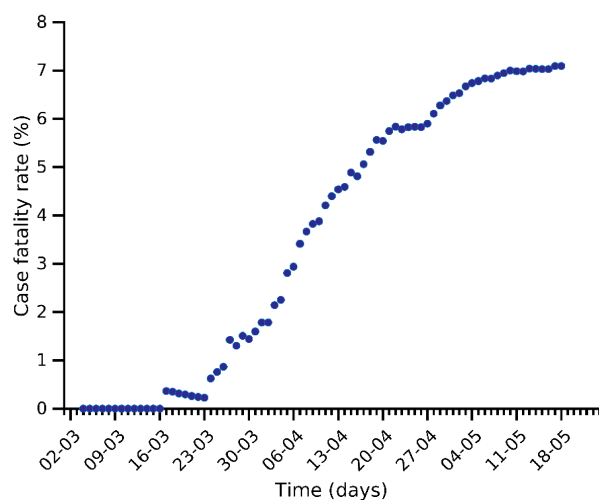
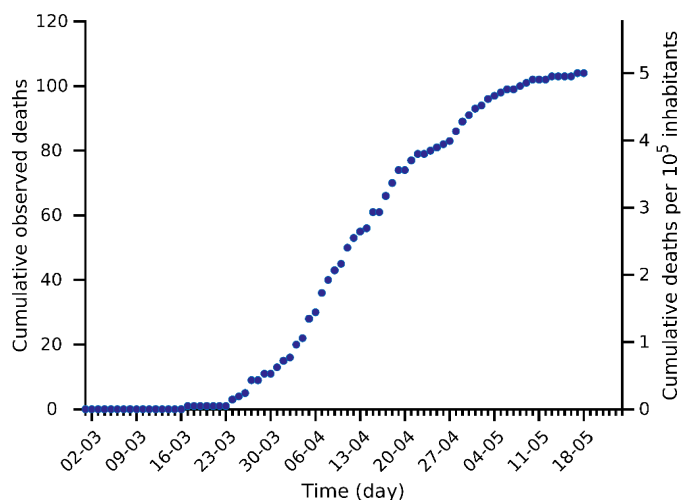
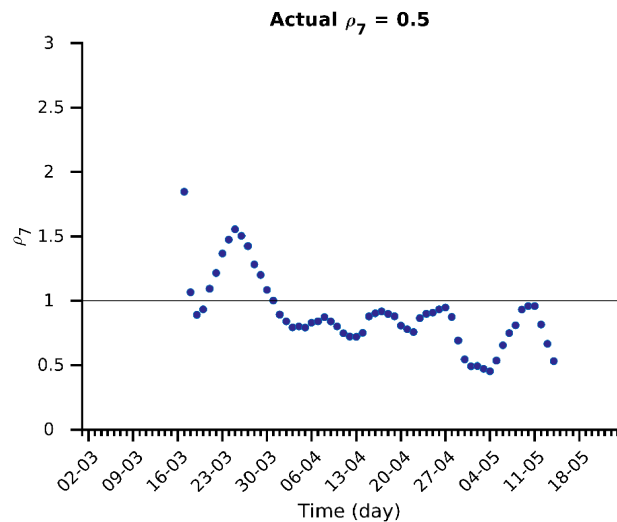
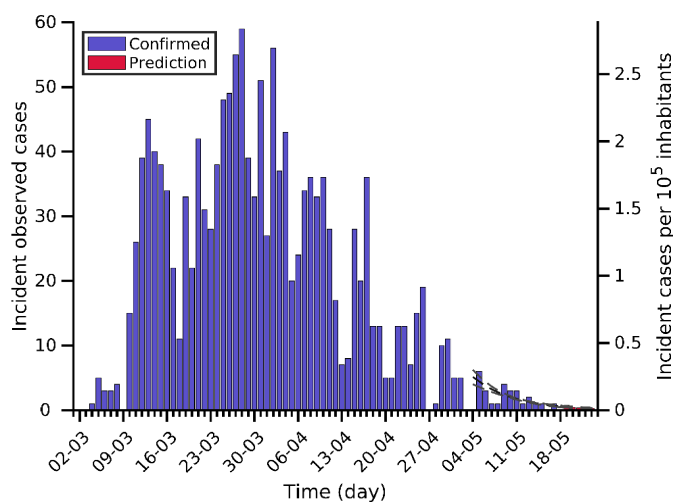
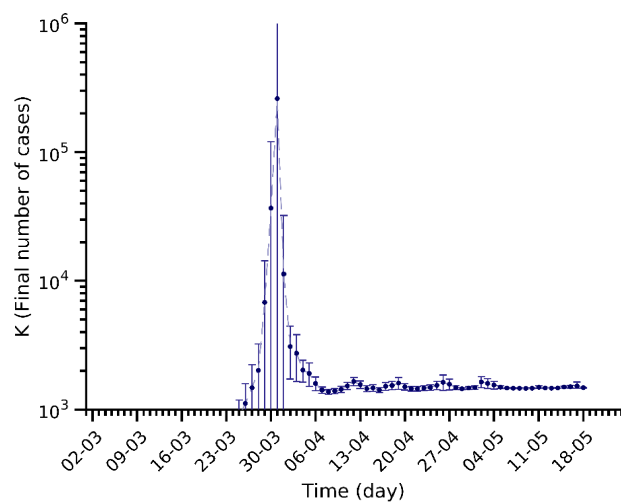
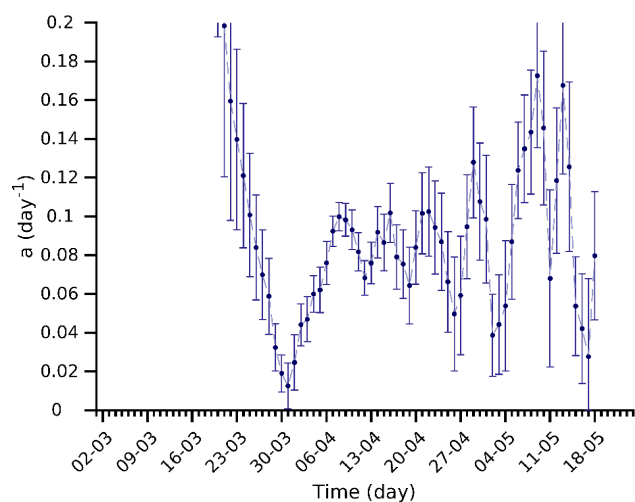
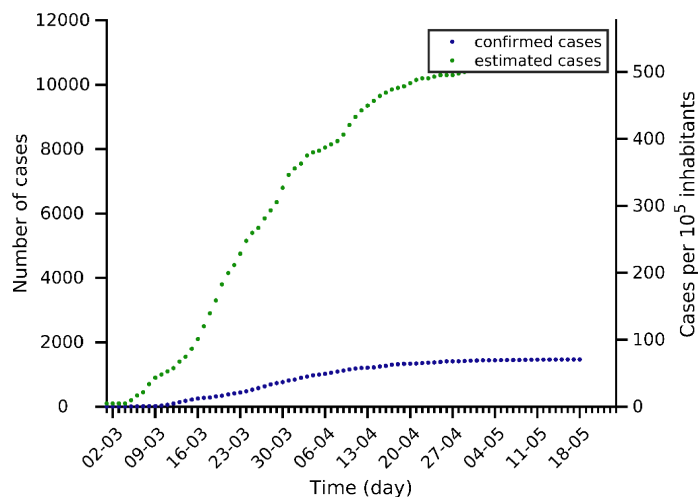
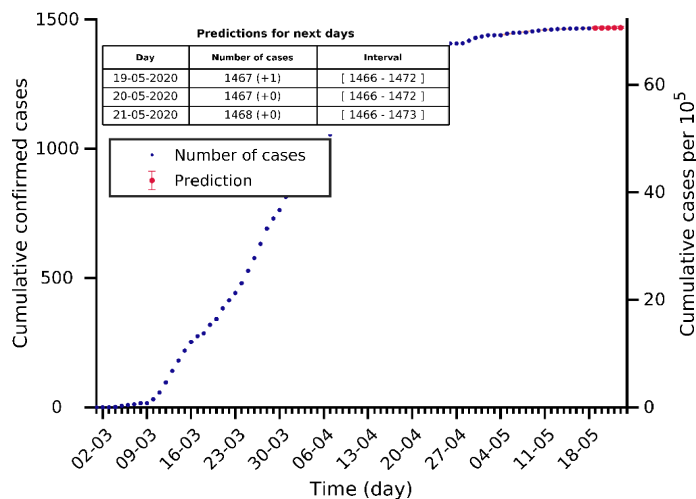
Lithuania 18-05-2020. Population: 2.7M. Current cumulated incidence: 57/10⁵



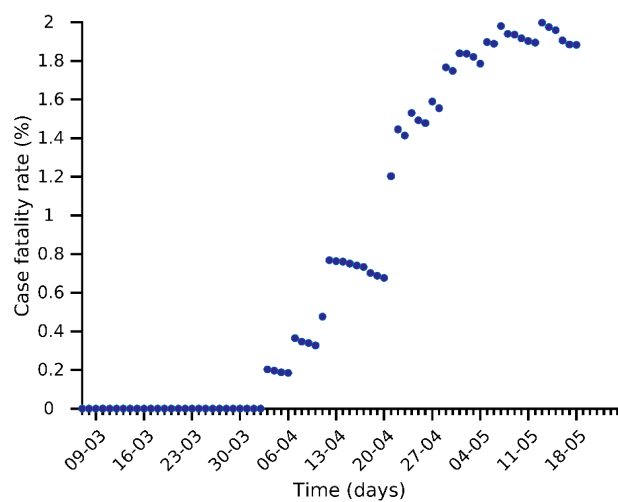
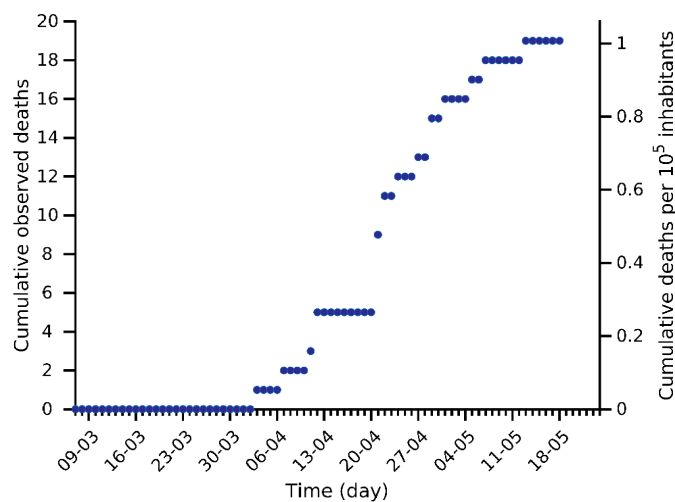
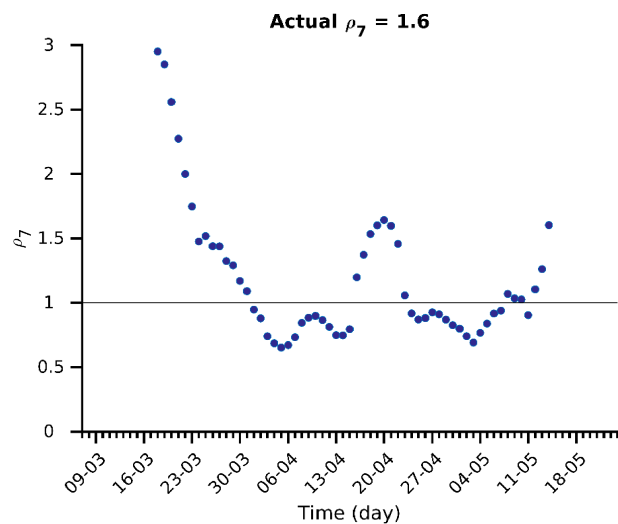
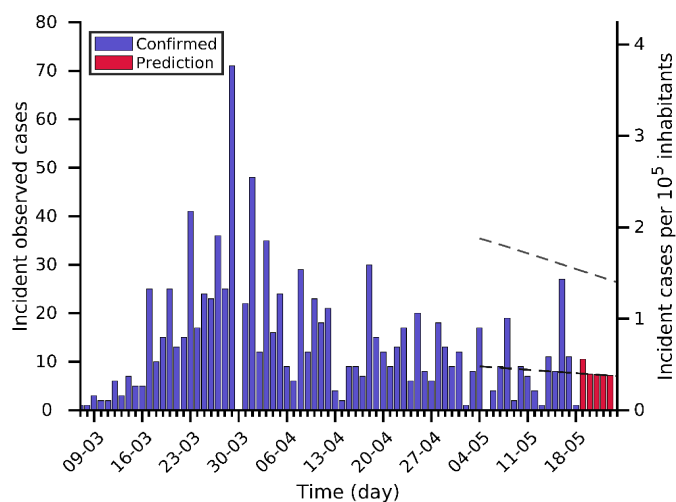
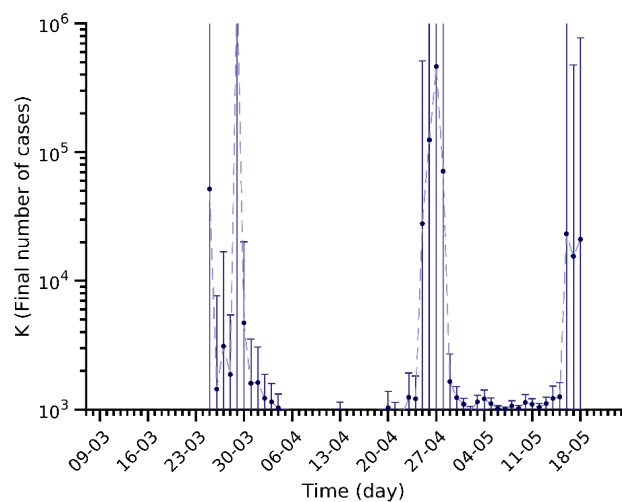
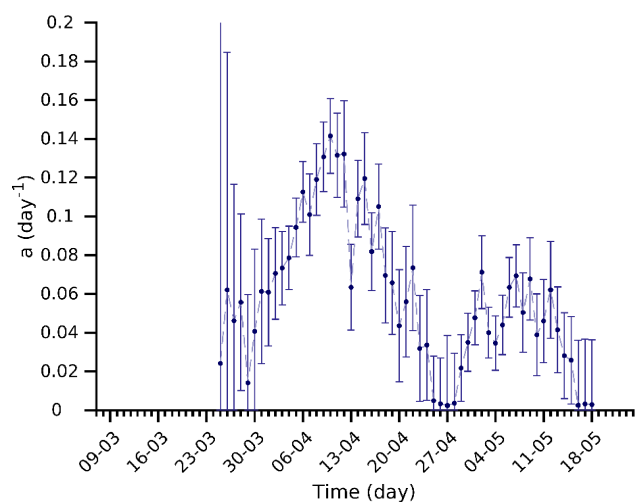
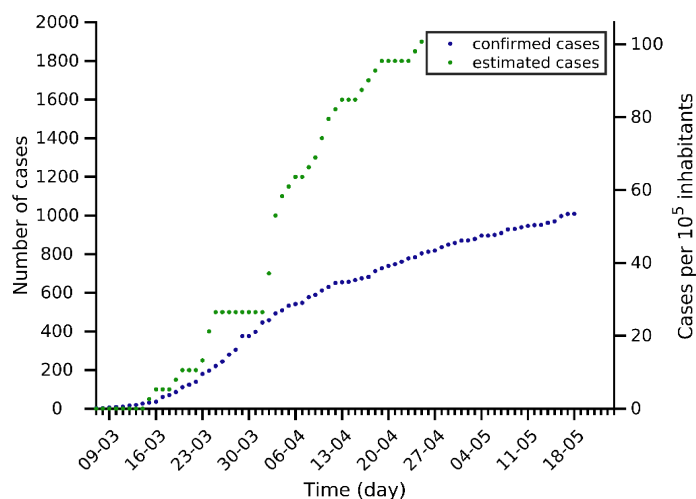
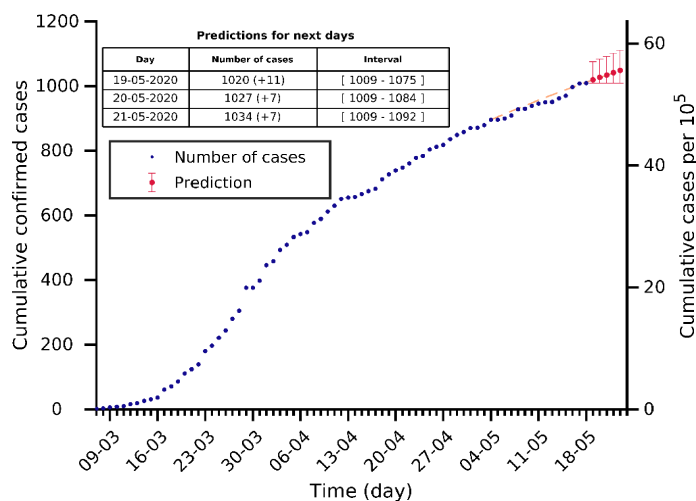
Slovakia 18-05-2020. Population: 5.5M. Current cumulated incidence: 27/10⁵



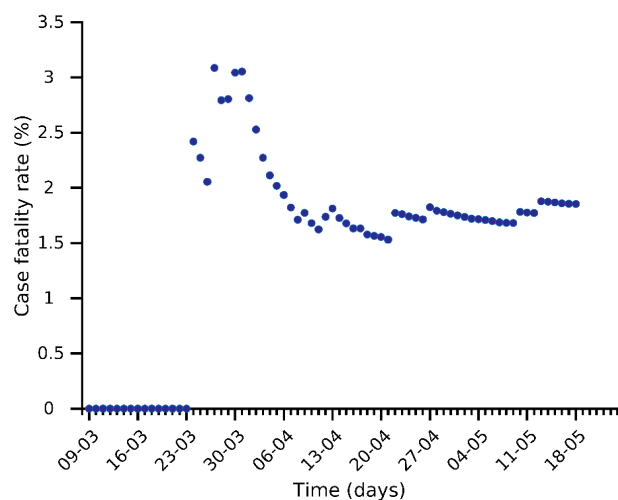
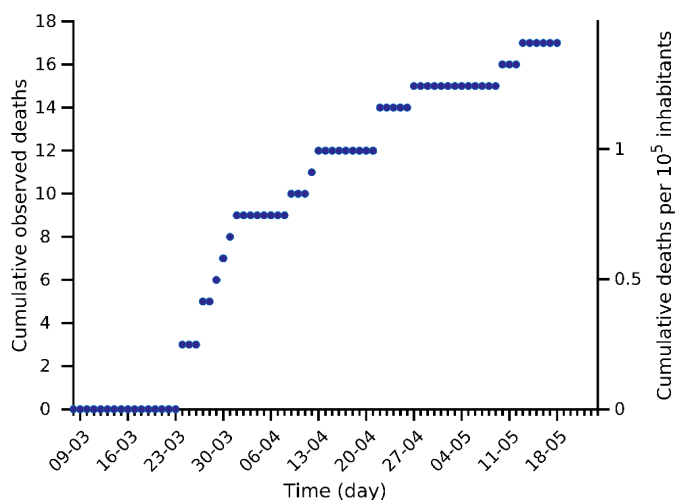
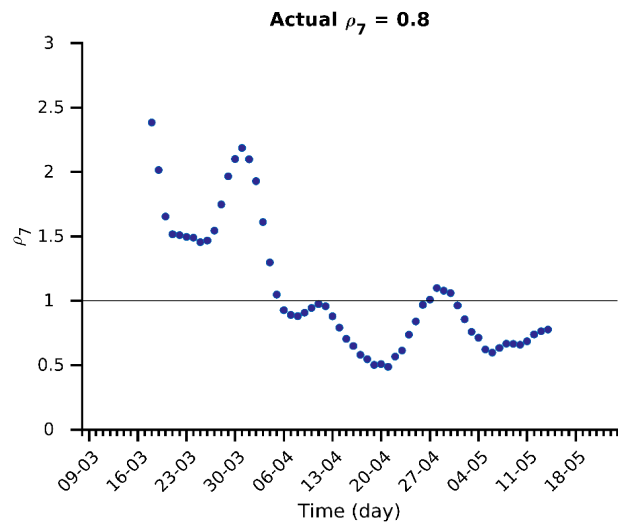
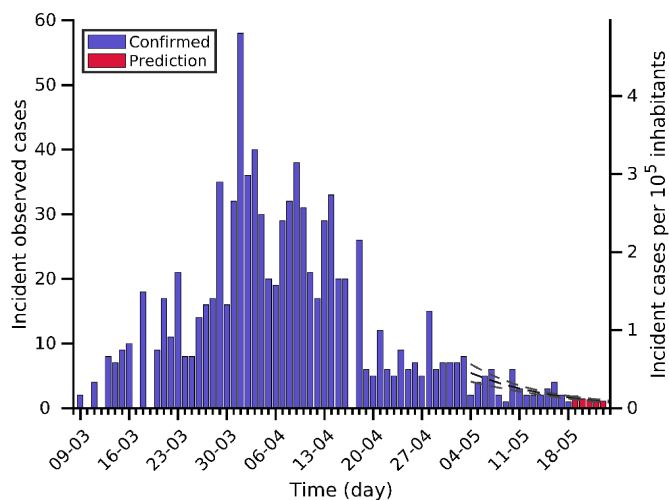
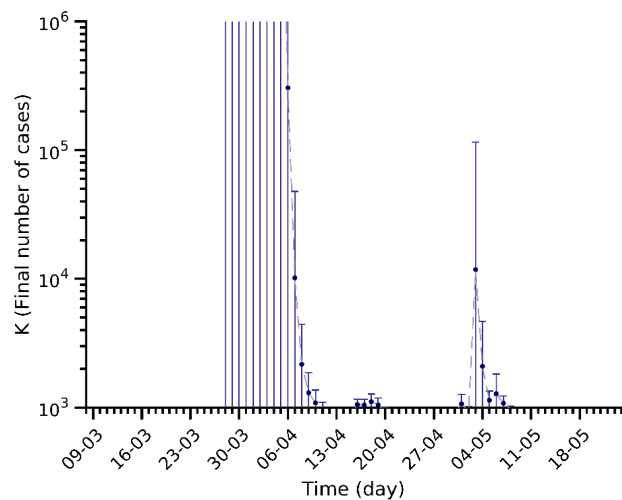
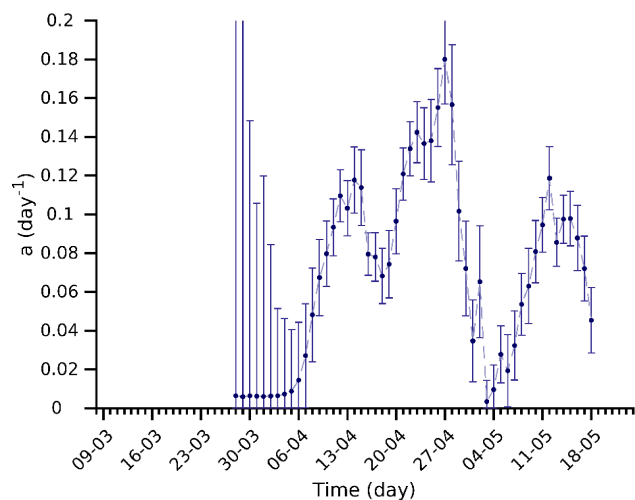
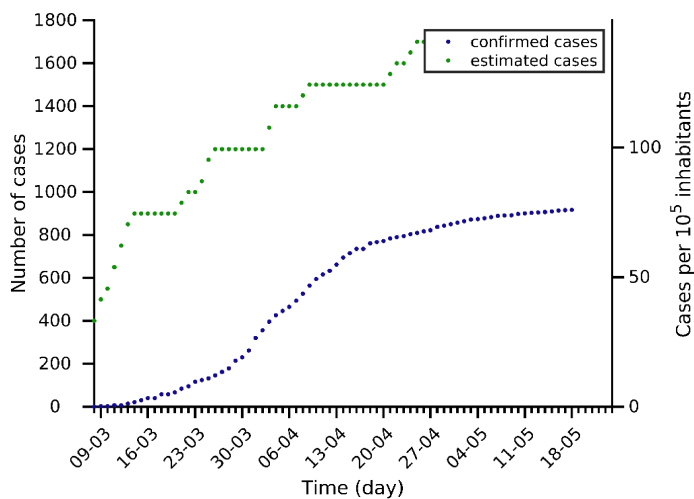
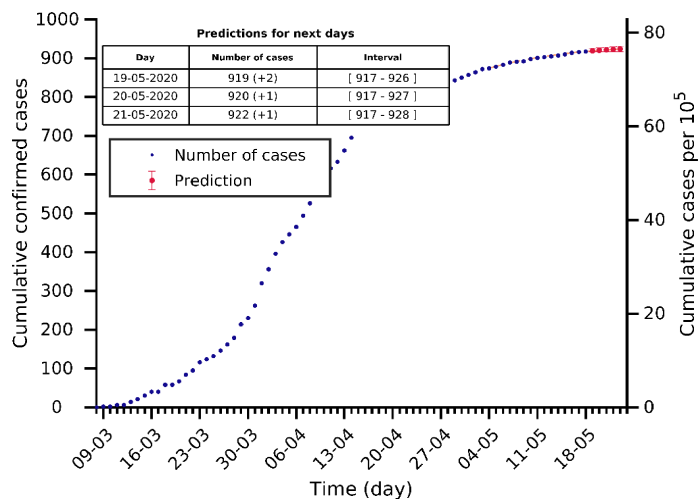
Slovenia 18-05-2020. Population: 2.1M. Current cumulated incidence: 71/10⁵



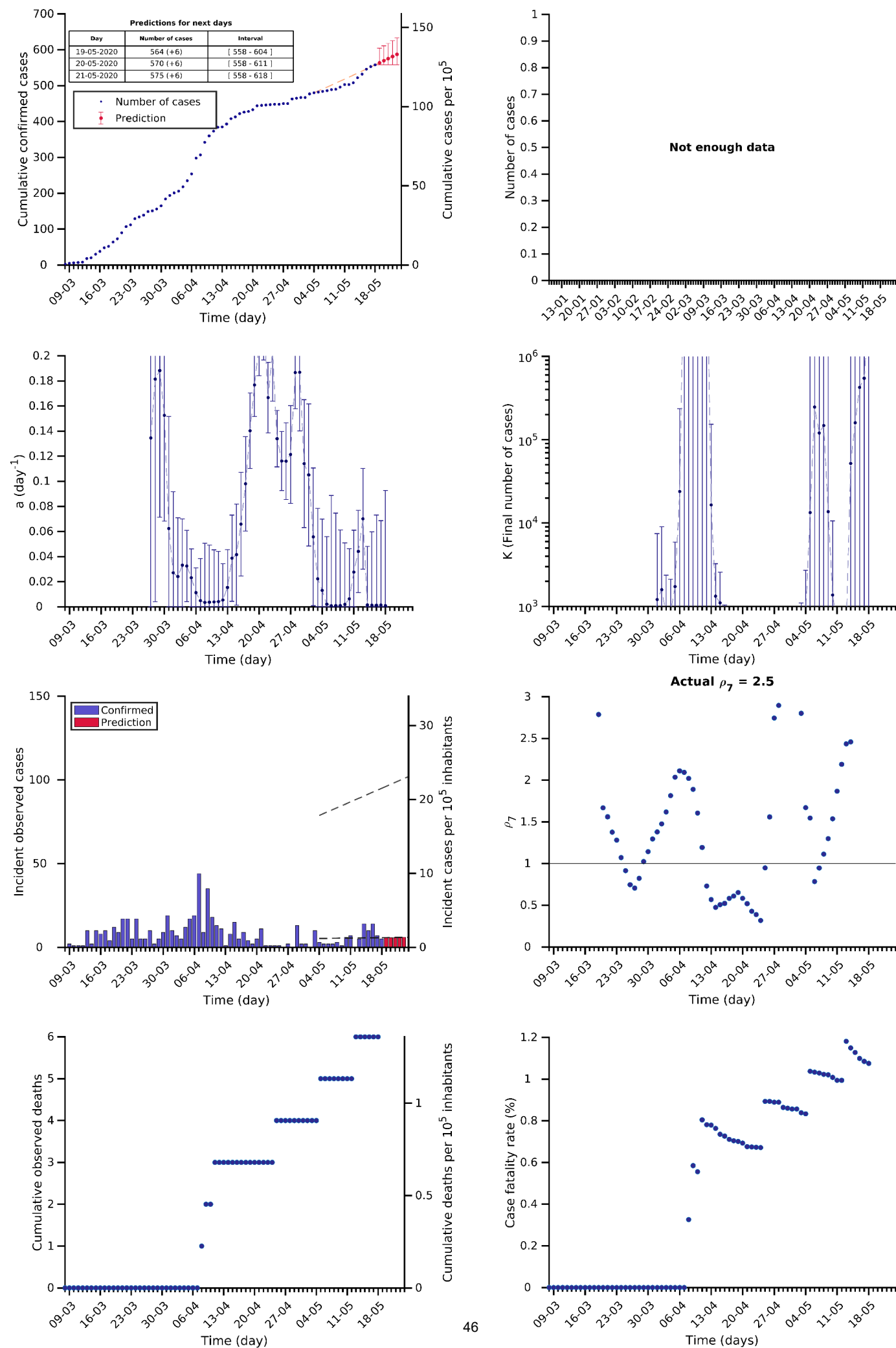
Latvia 18-05-2020. Population: 1.9M. Current cumulated incidence: 53/10⁵



Cyprus 18-05-2020. Population: 1.2M. Current cumulated incidence: 76/10⁵



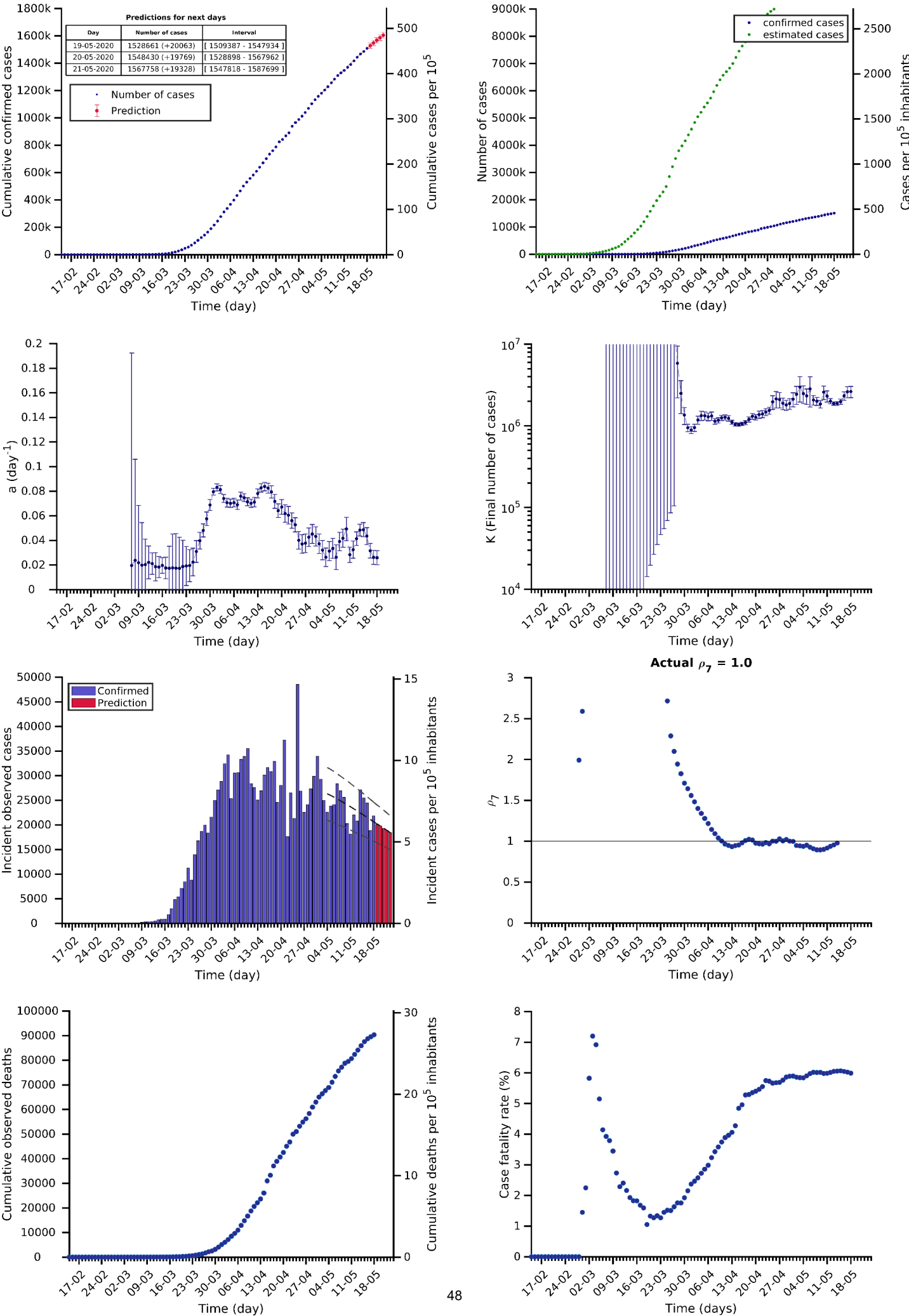
Malta 18-05-2020. Population: 0.4M. Current cumulated incidence: 126/10⁵



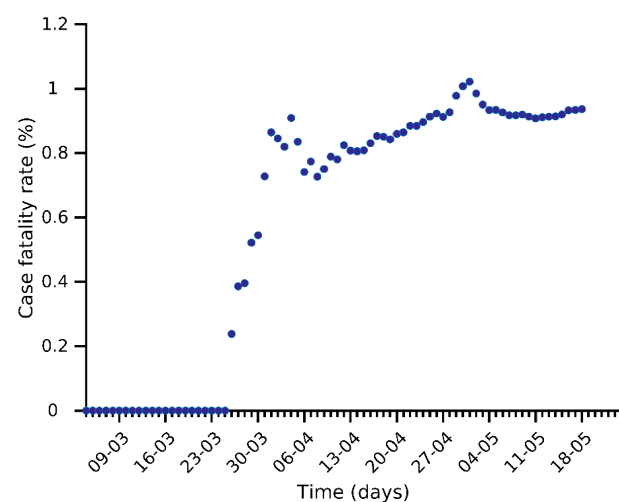
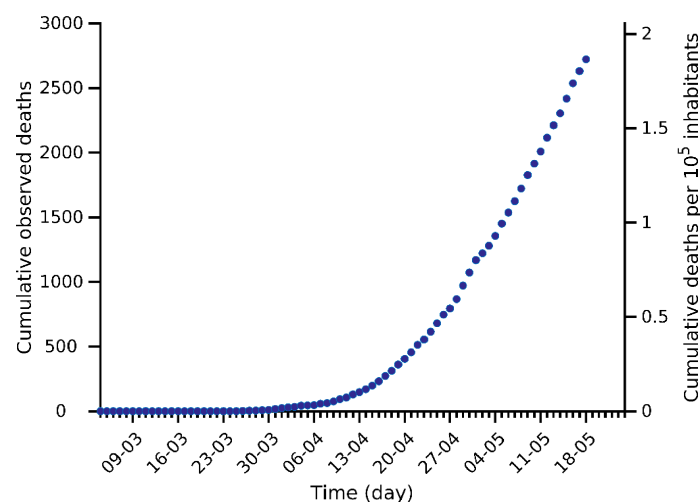
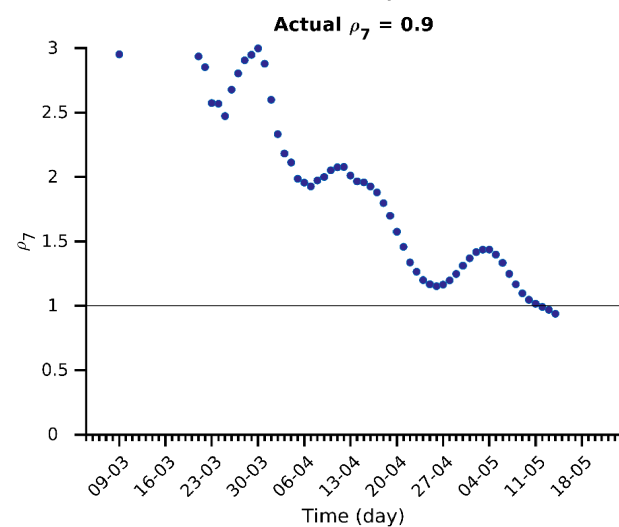
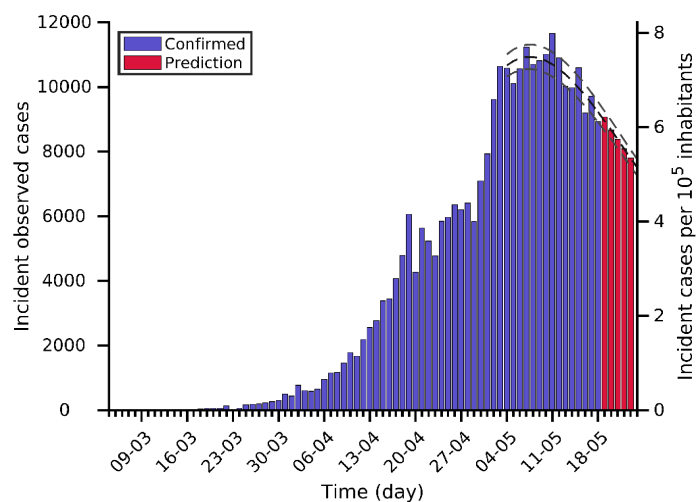
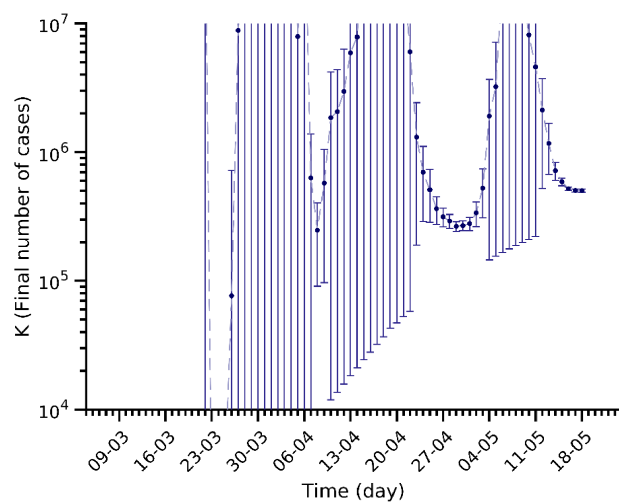
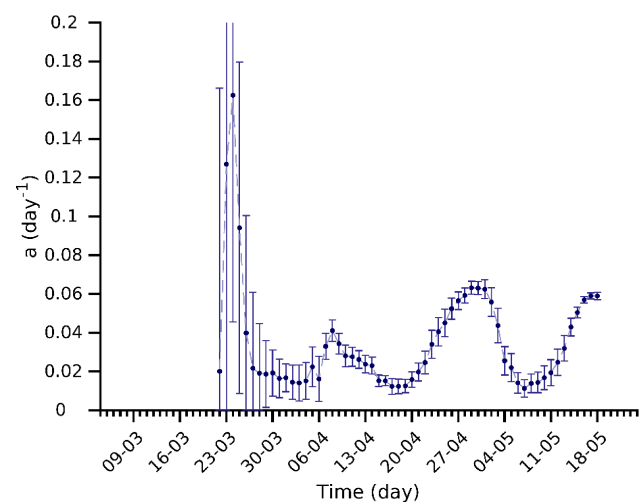
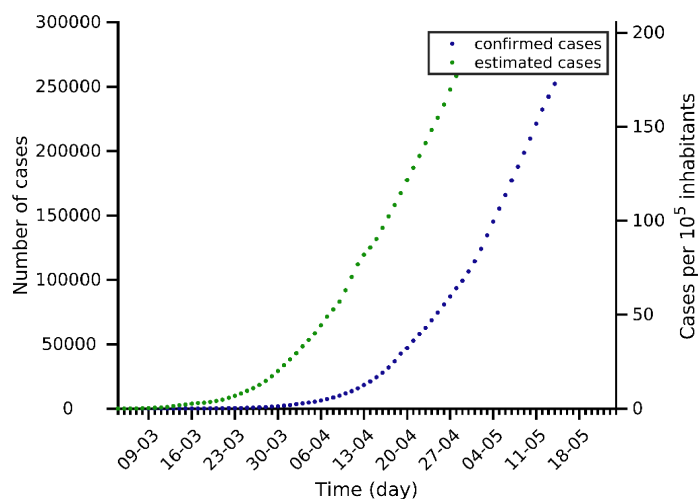
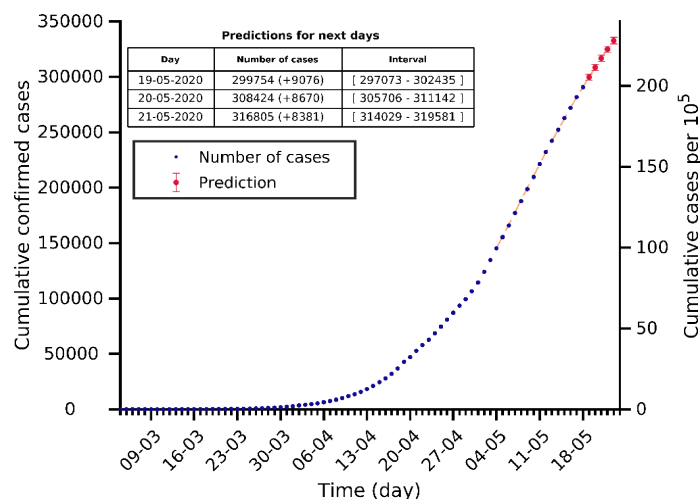
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

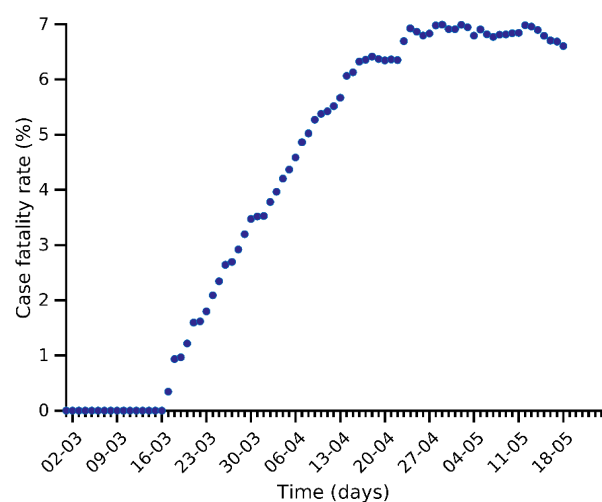
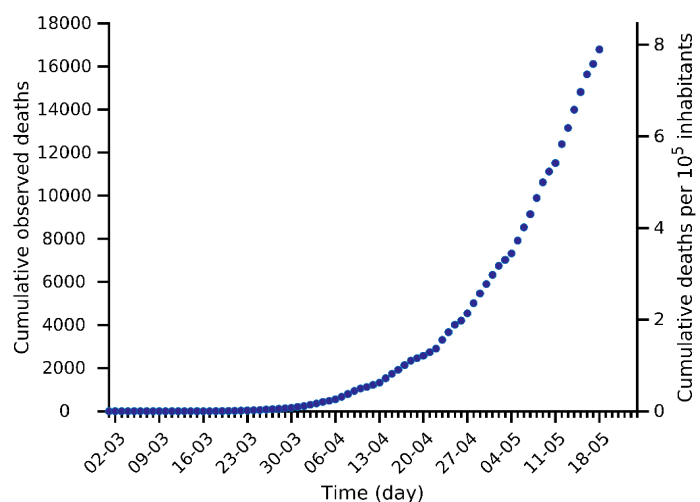
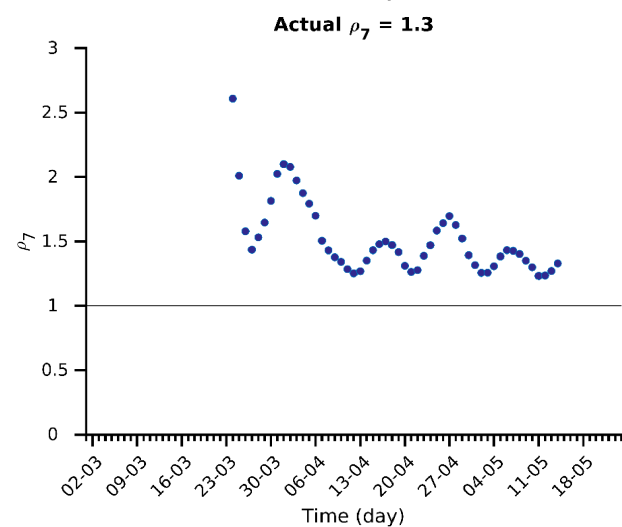
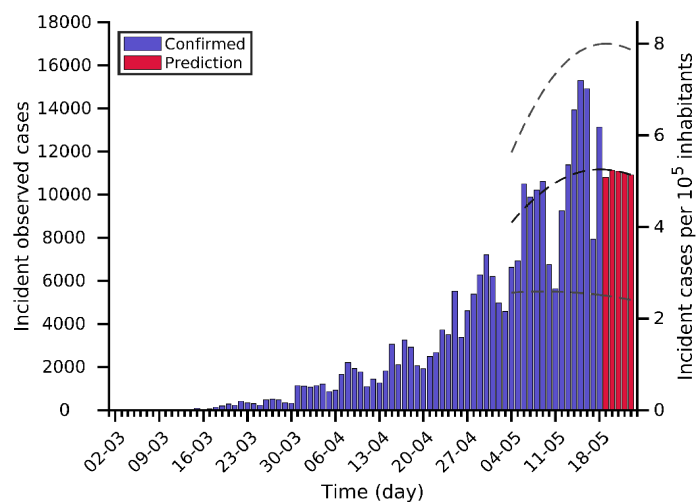
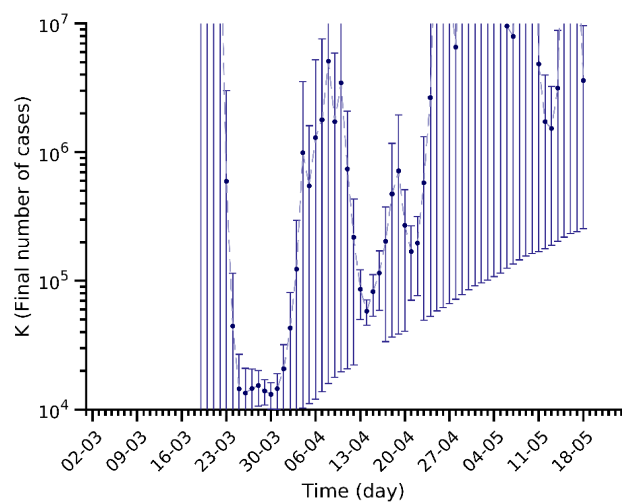
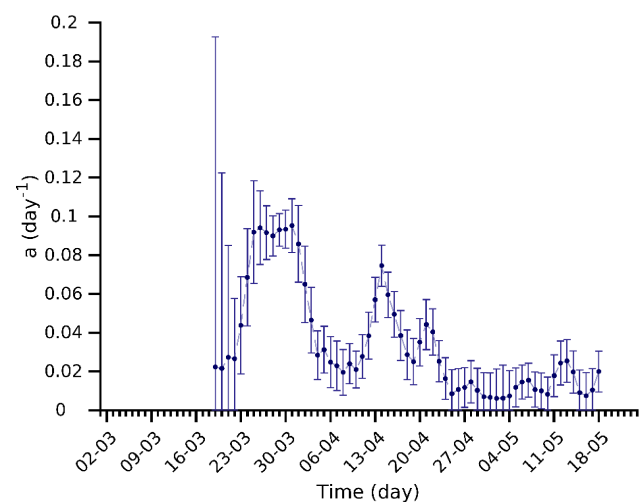
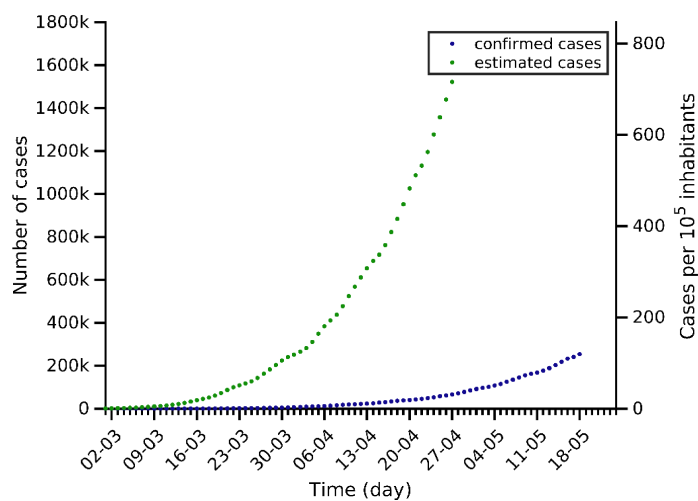
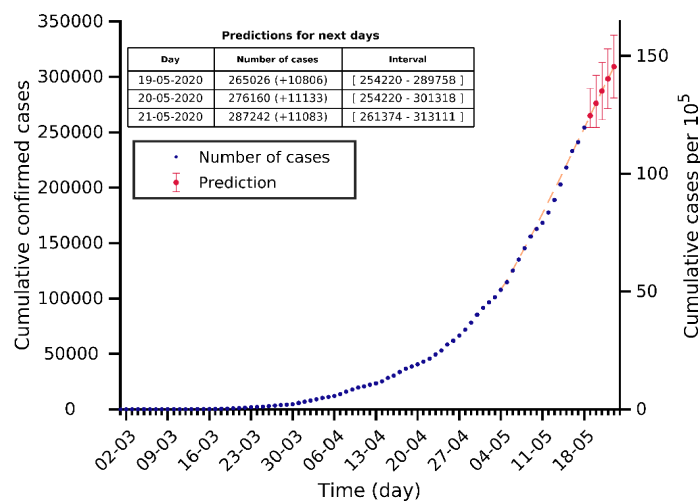
USA 18-05-2020. Population: 331.0M. Current cumulated incidence: 456/10⁵



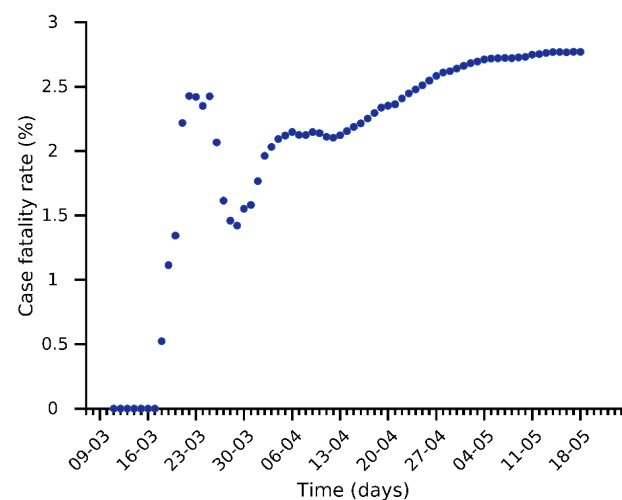
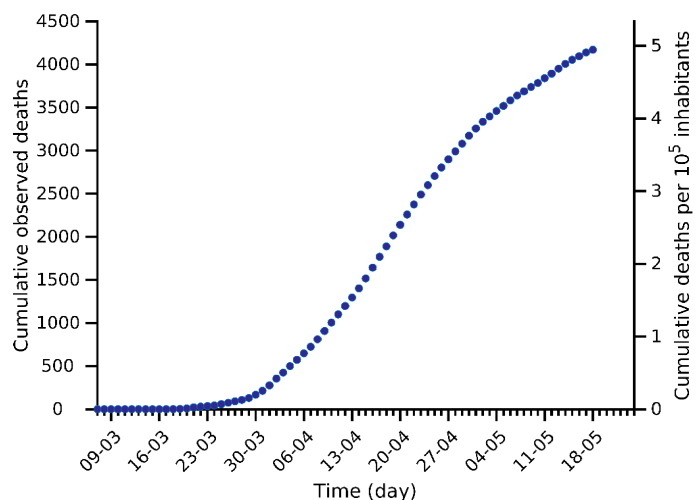
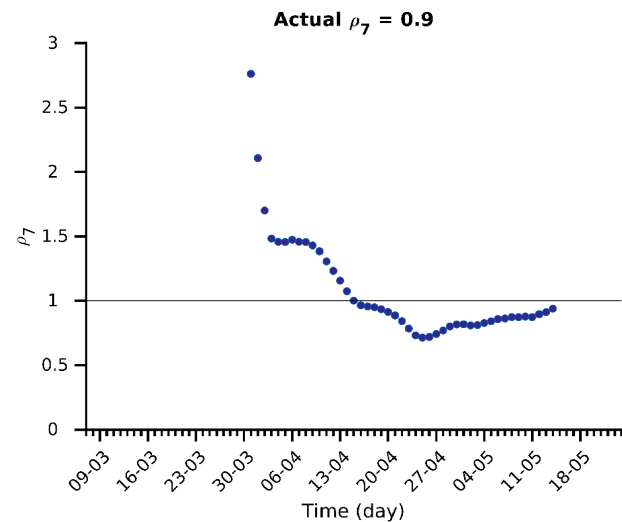
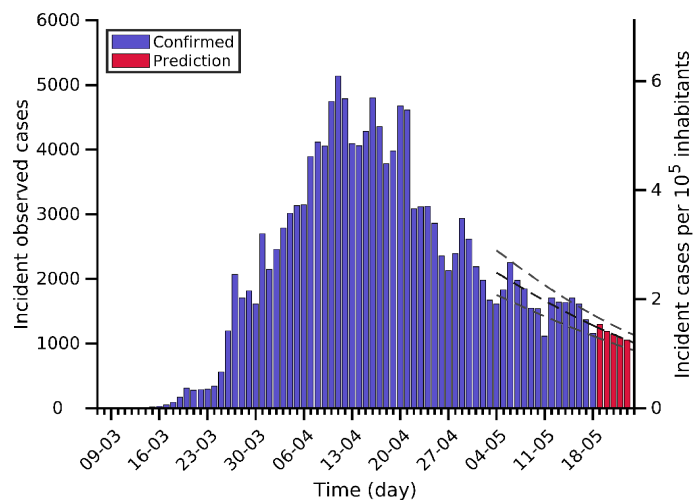
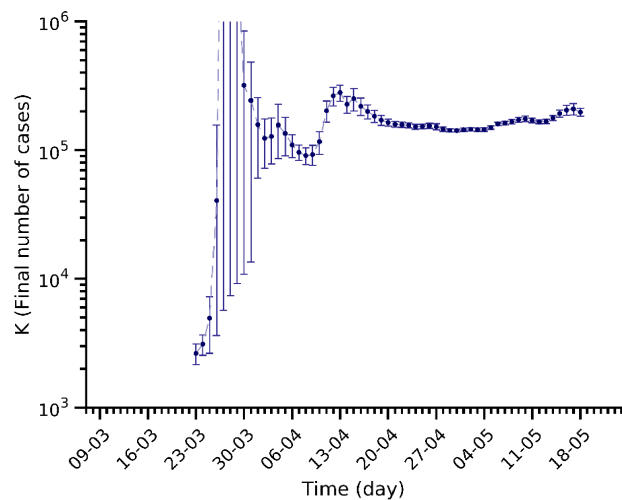
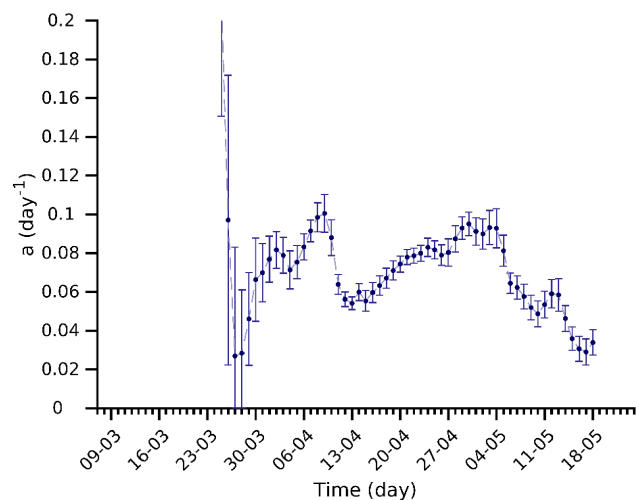
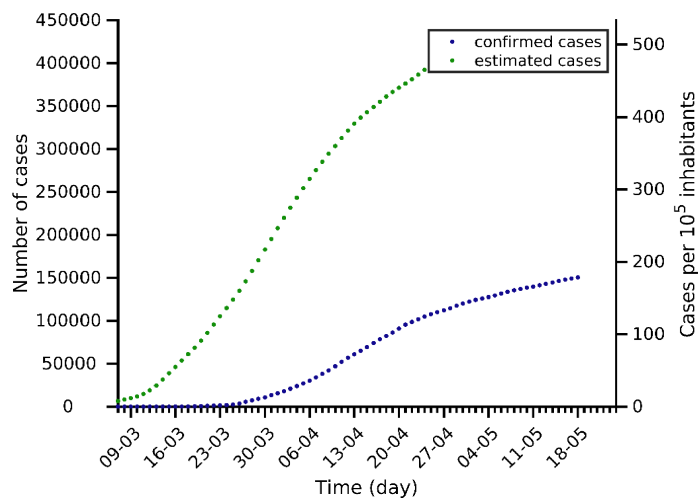
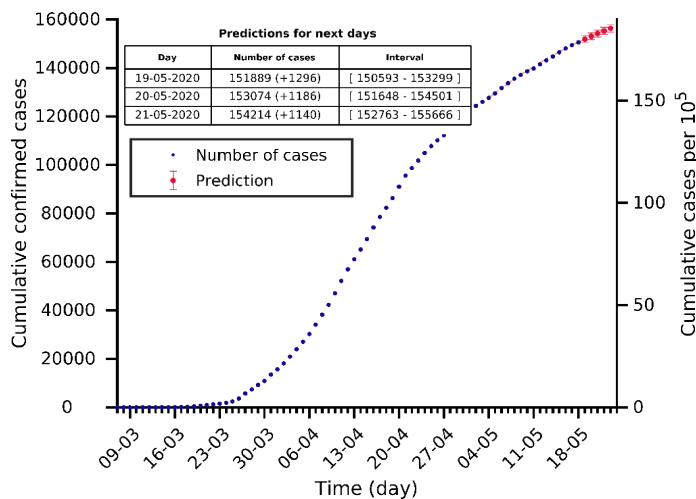
Russia 18-05-2020. Population: 145.9M. Current cumulated incidence: 199/10⁵



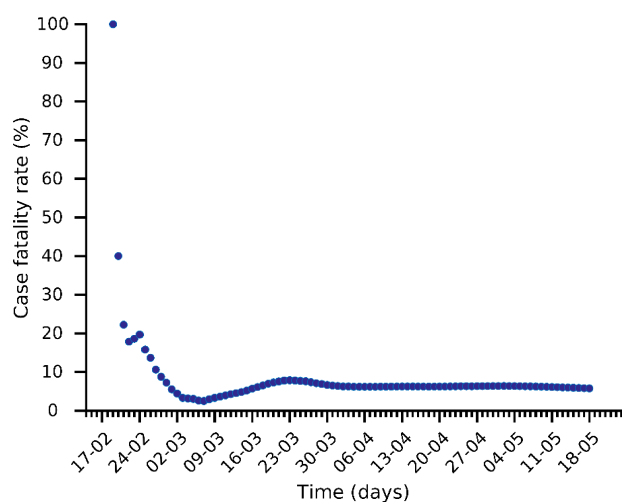
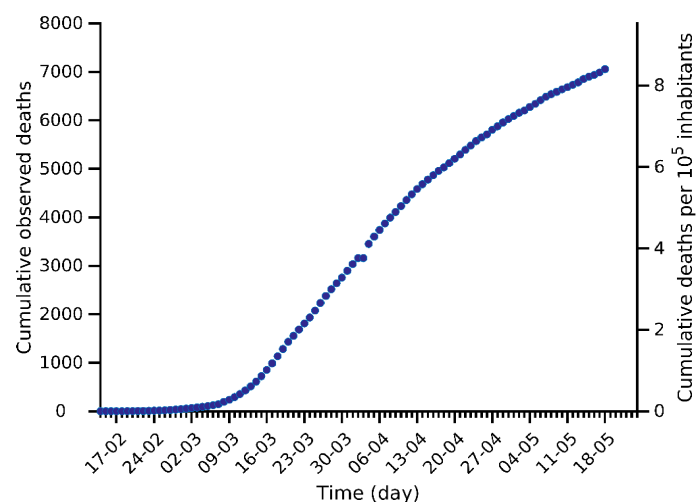
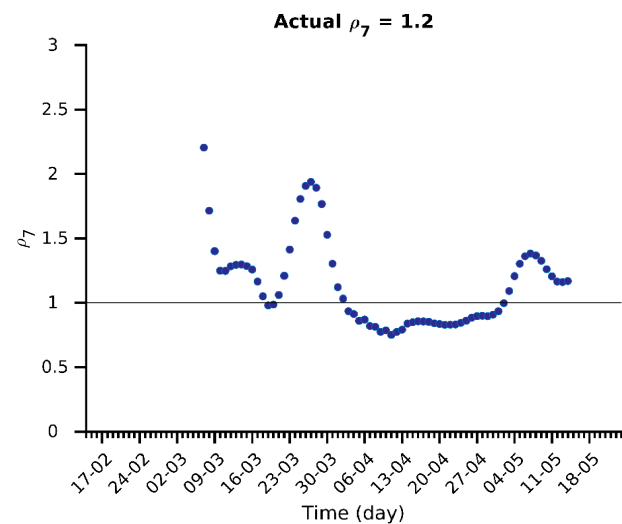
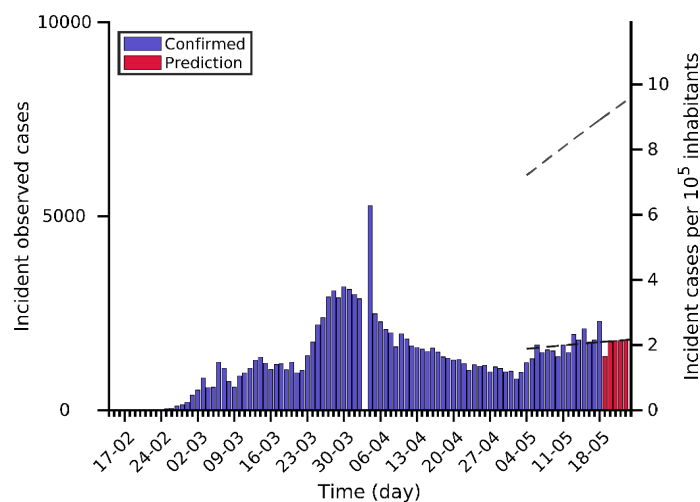
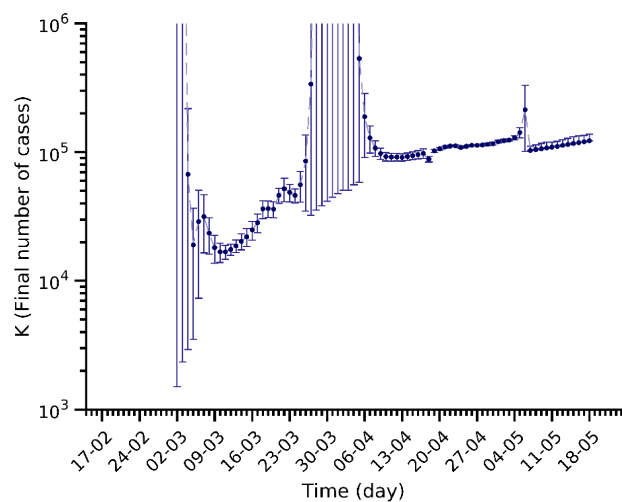
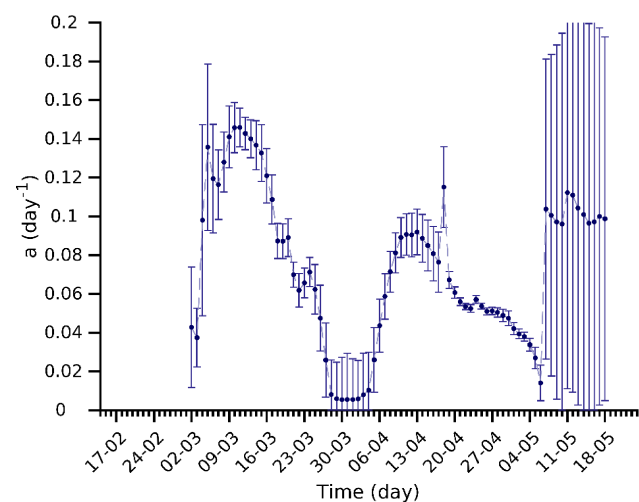
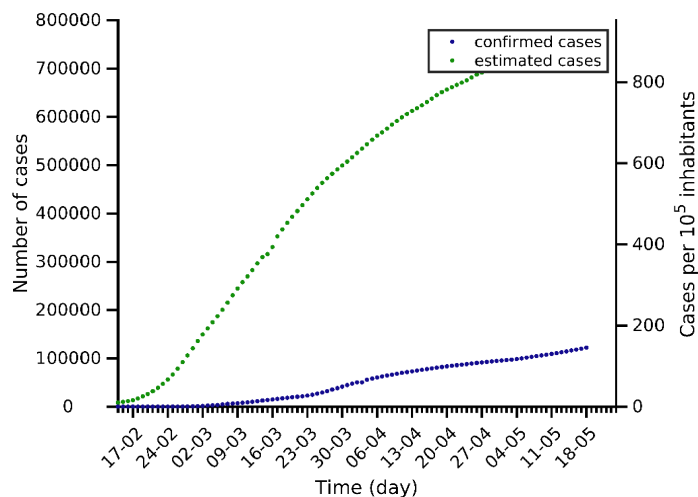
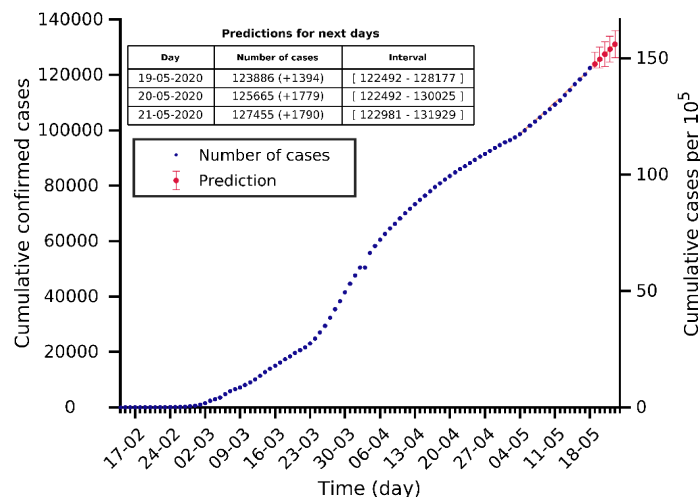
Brazil 18-05-2020. Population: 212.6M. Current cumulated incidence: 120/10⁵



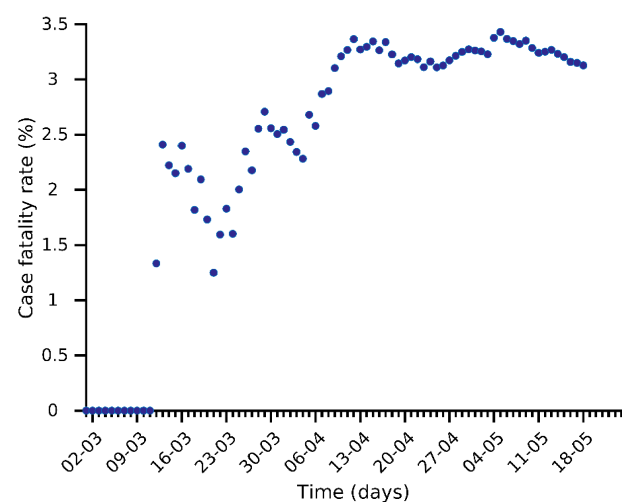
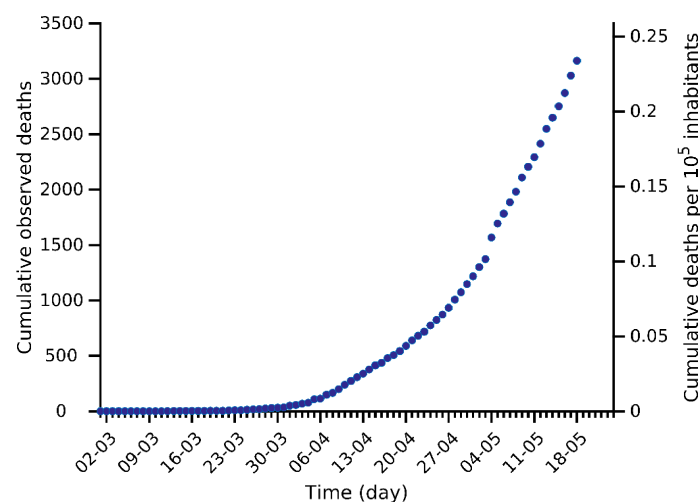
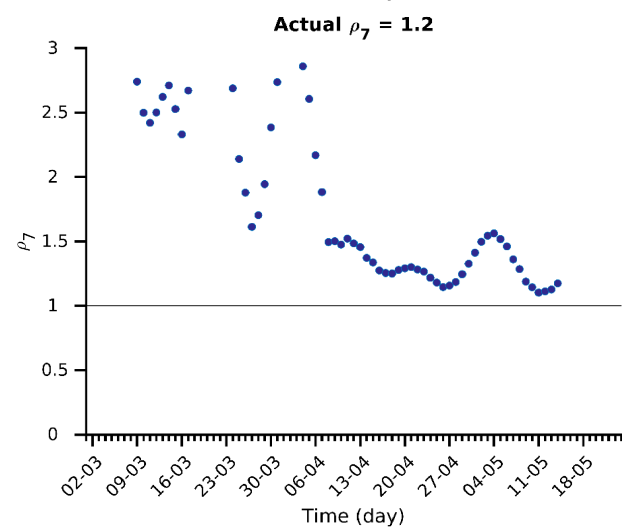
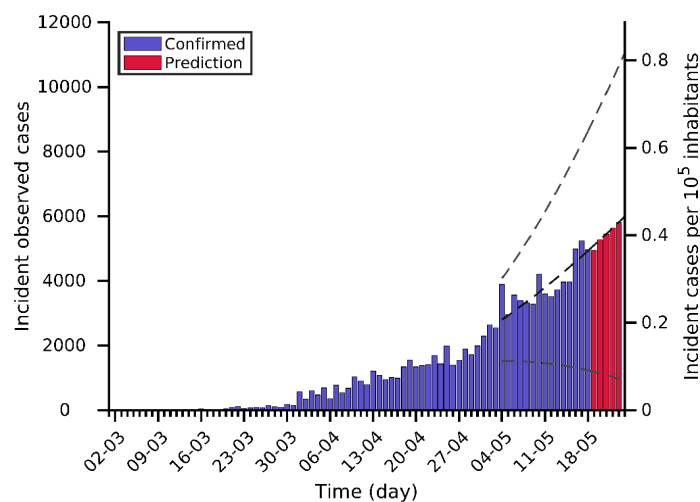
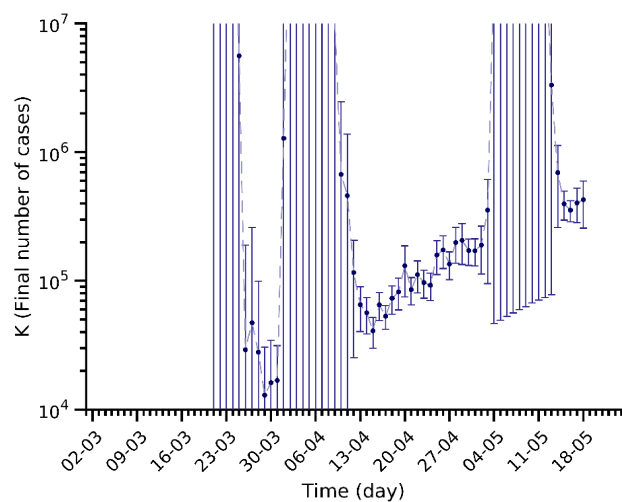
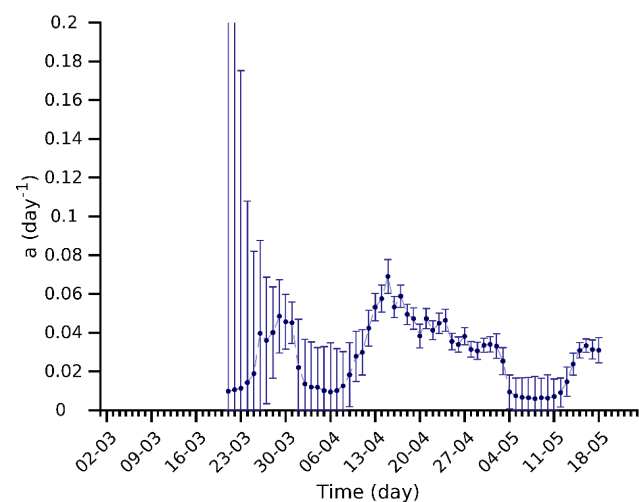
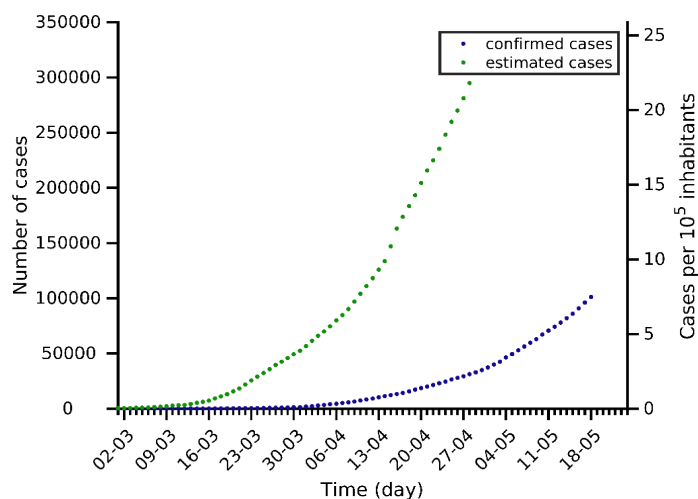
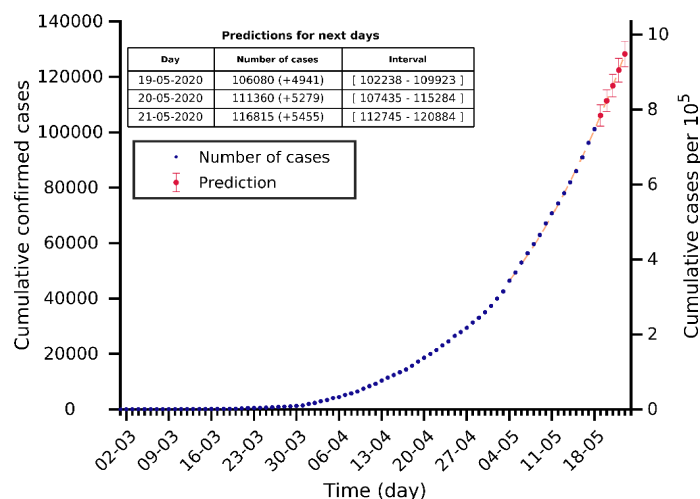
Turkey 18-05-2020. Population: 84.3M. Current cumulated incidence: 179/10⁵



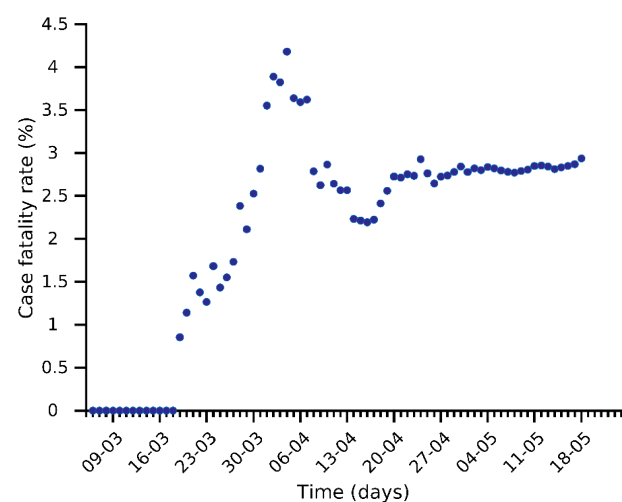
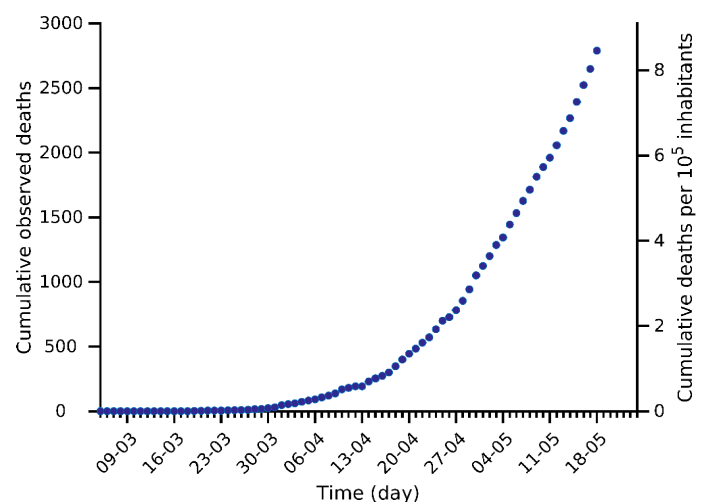
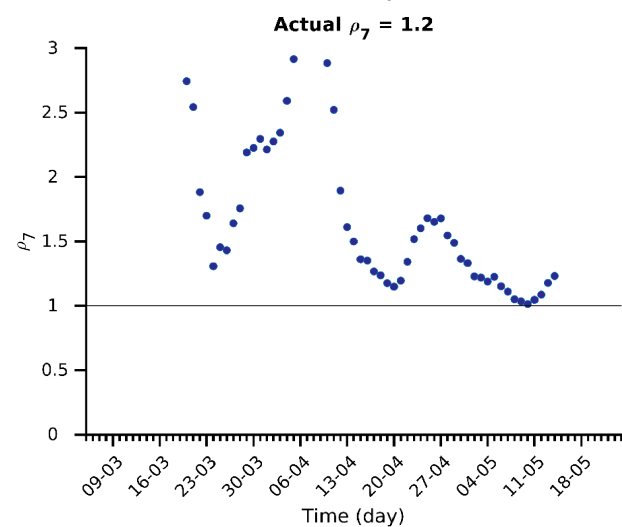
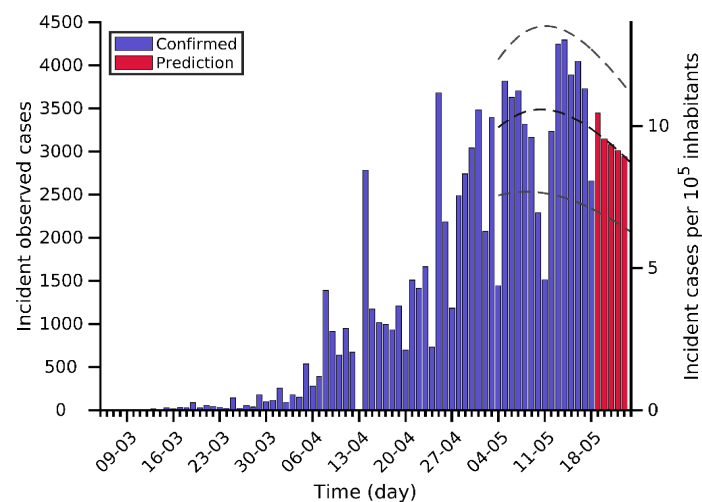
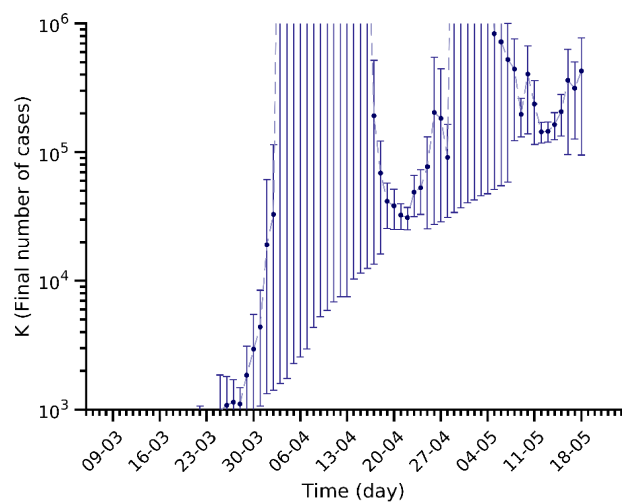
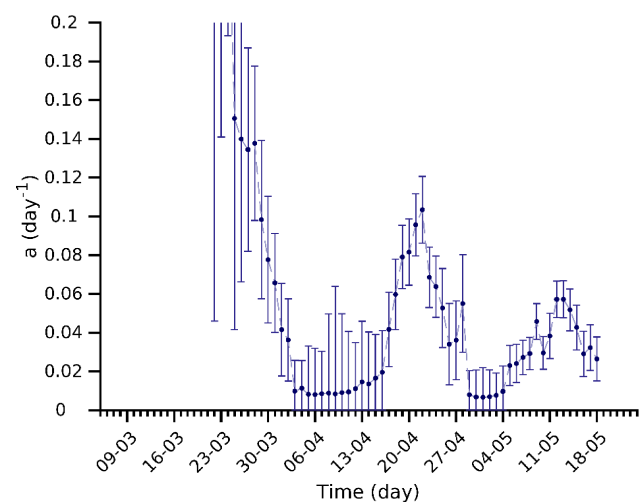
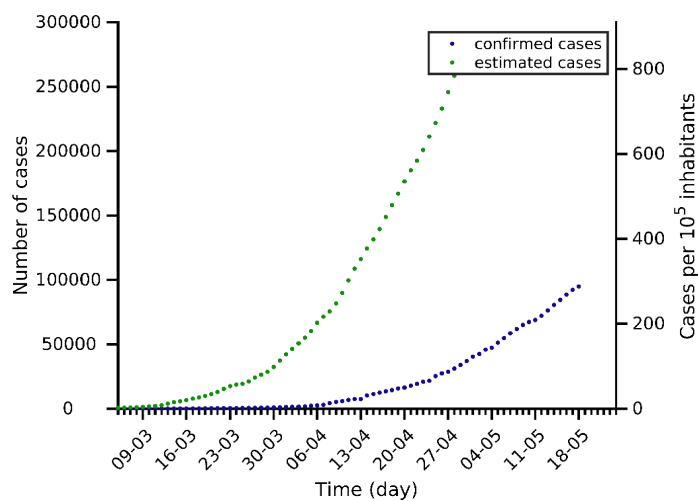
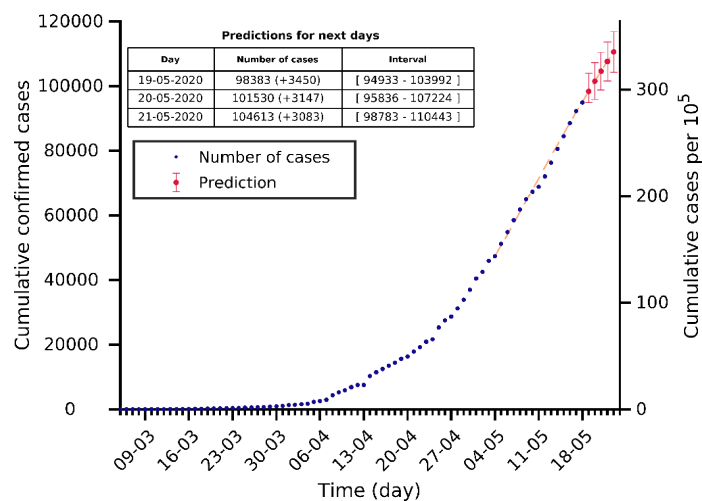
Iran 18-05-2020. Population: 84.0M. Current cumulated incidence: 146/10⁵



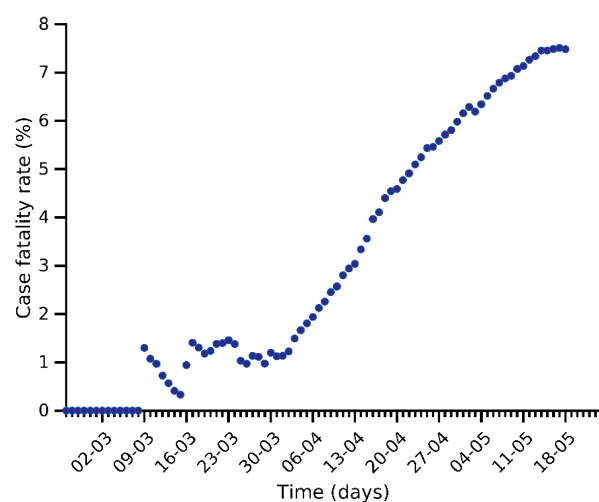
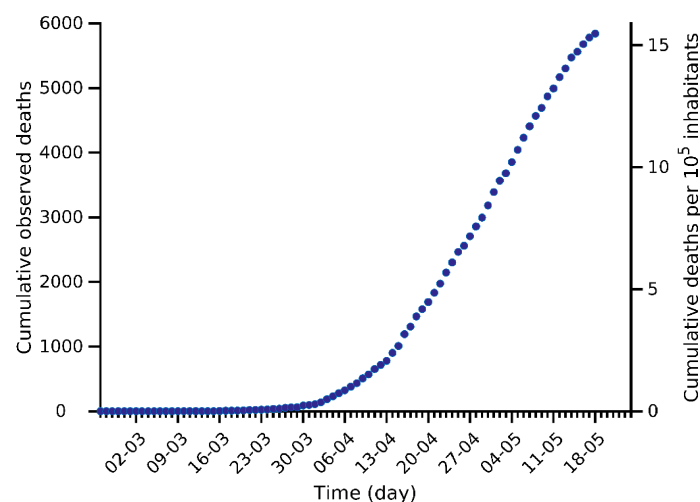
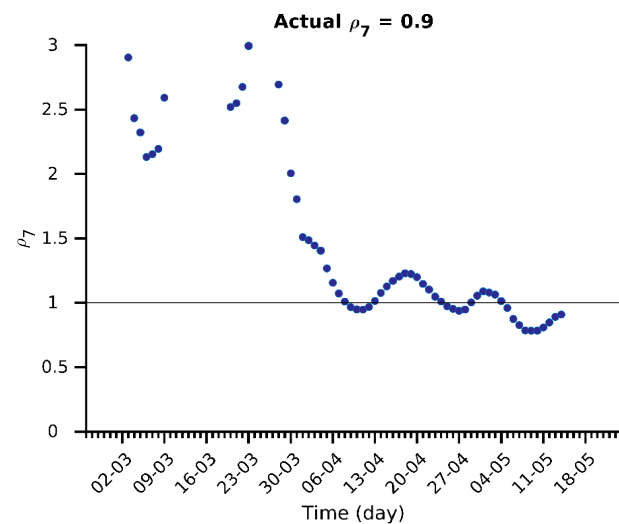
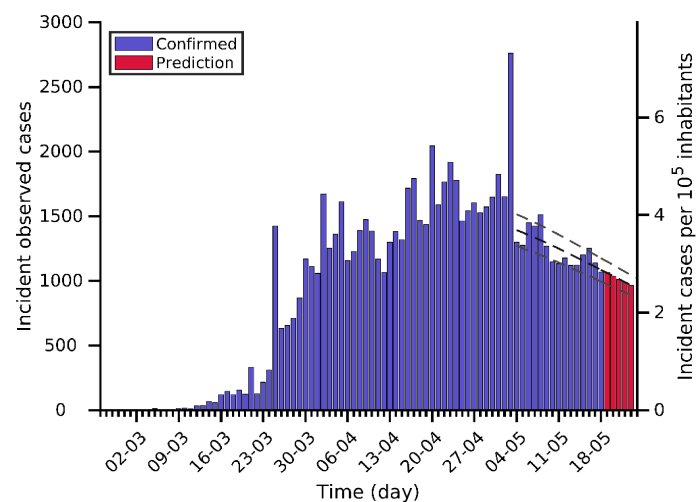
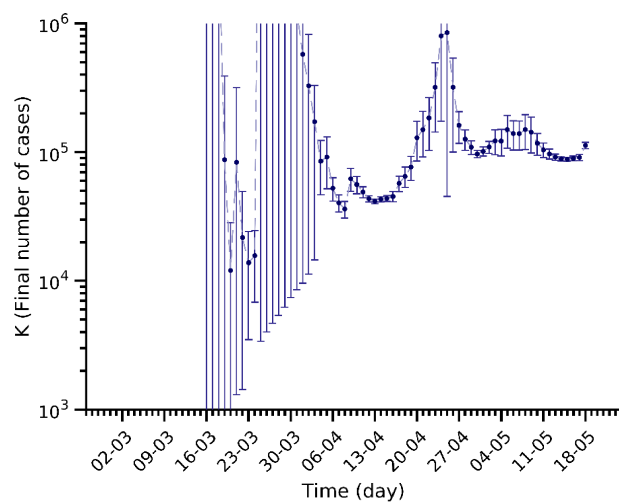
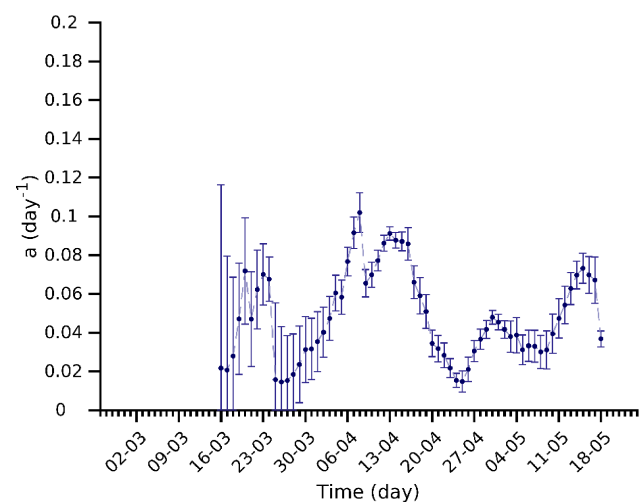
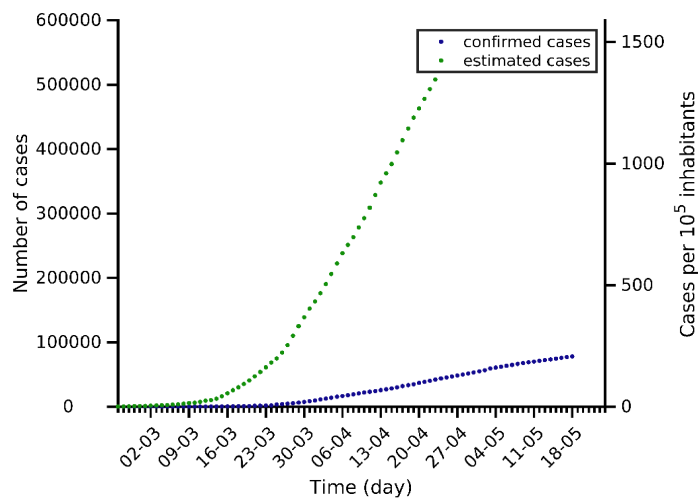
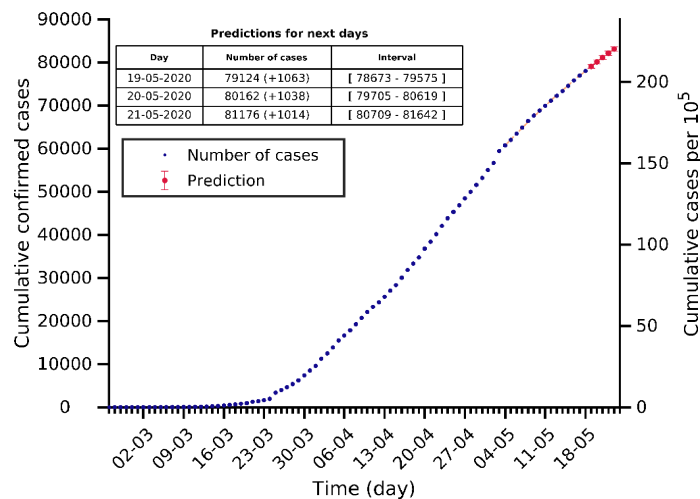
India 18-05-2020. Population: 1353.0M. Current cumulated incidence: 7/10⁵



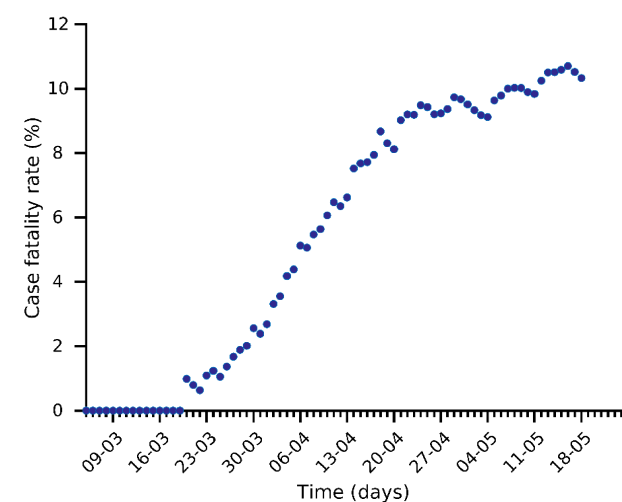
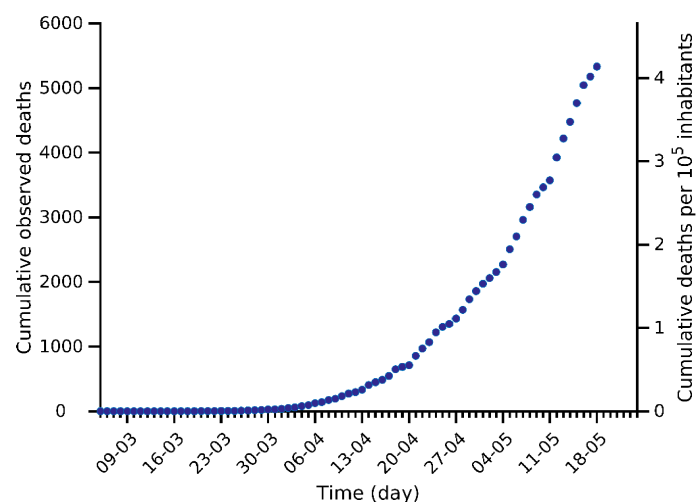
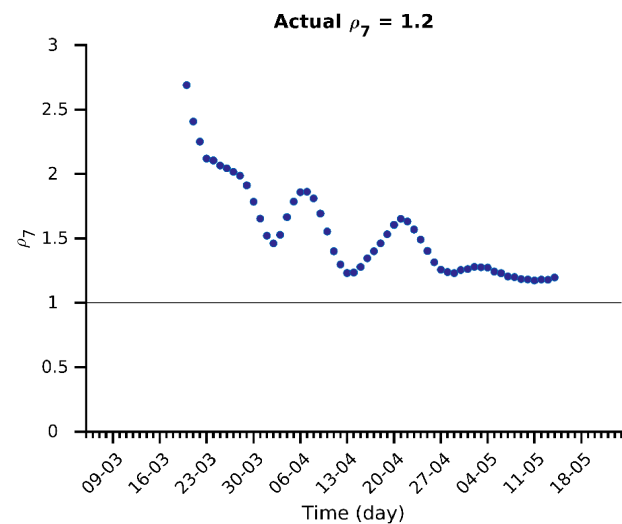
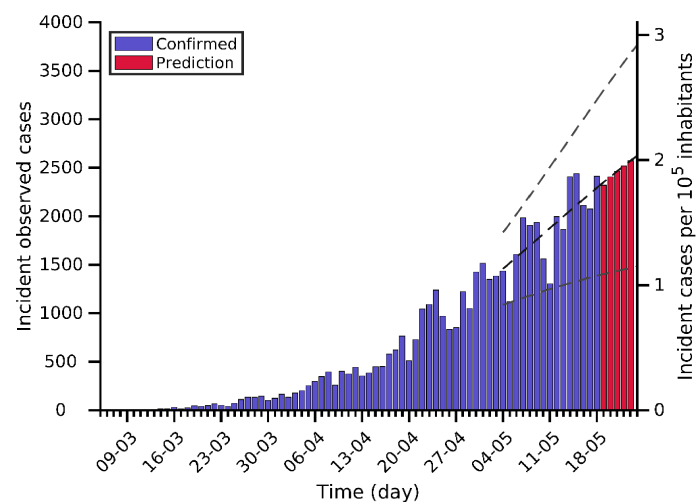
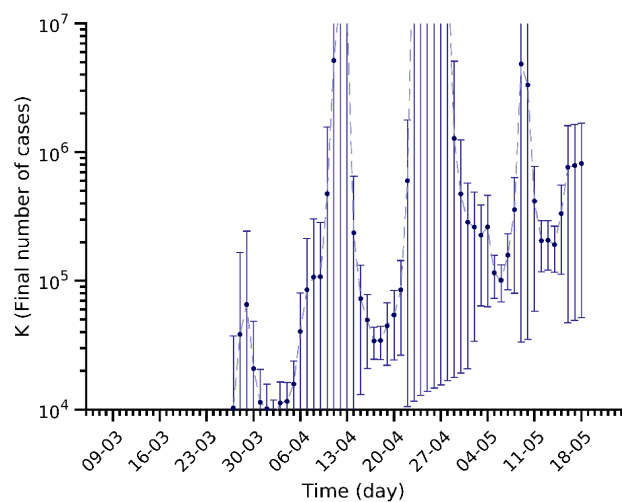
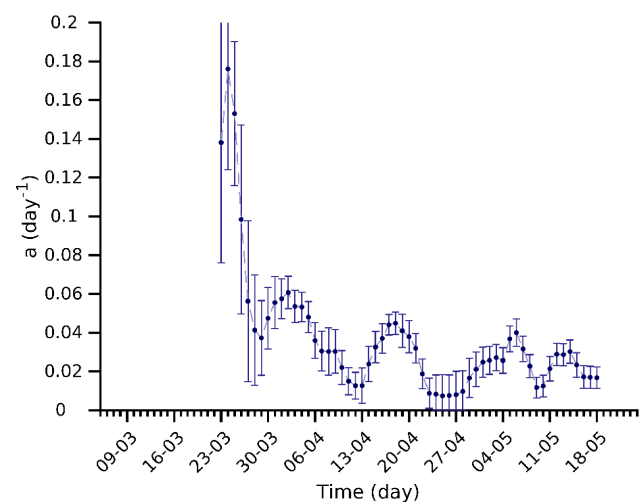
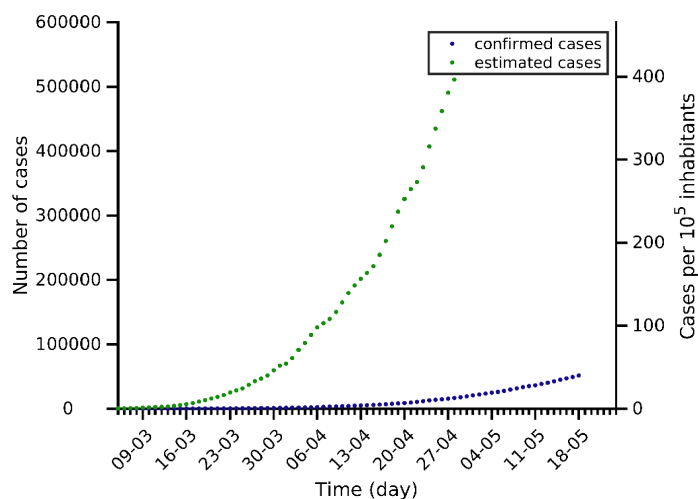
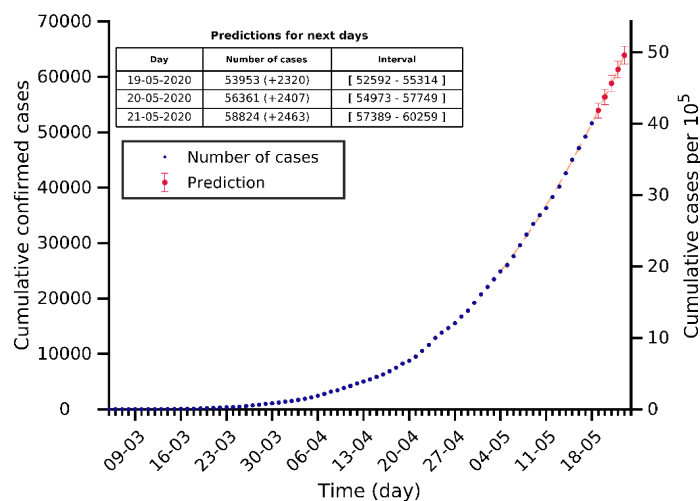
Peru 18-05-2020. Population: 33.0M. Current cumulated incidence: 288/10⁵



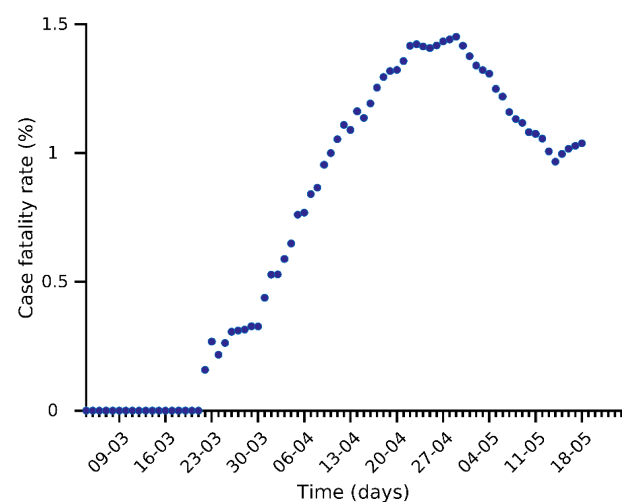
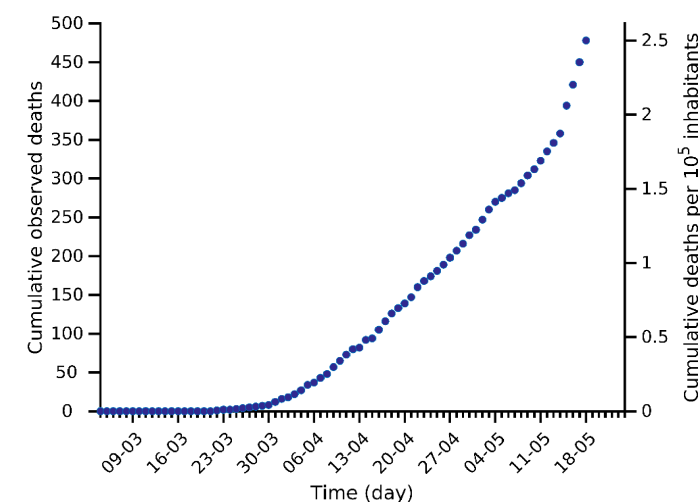
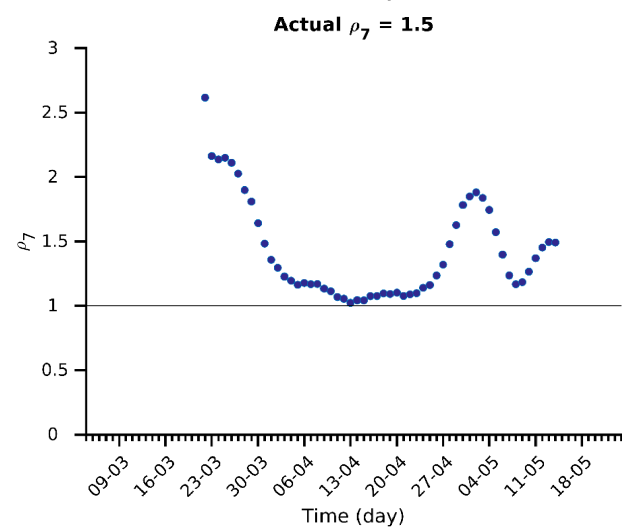
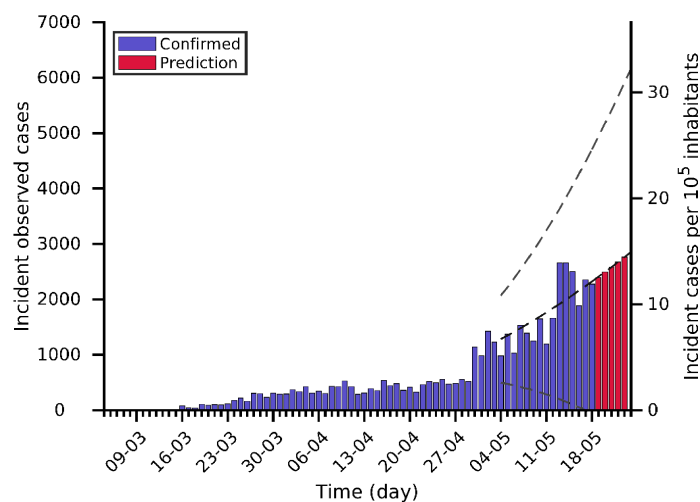
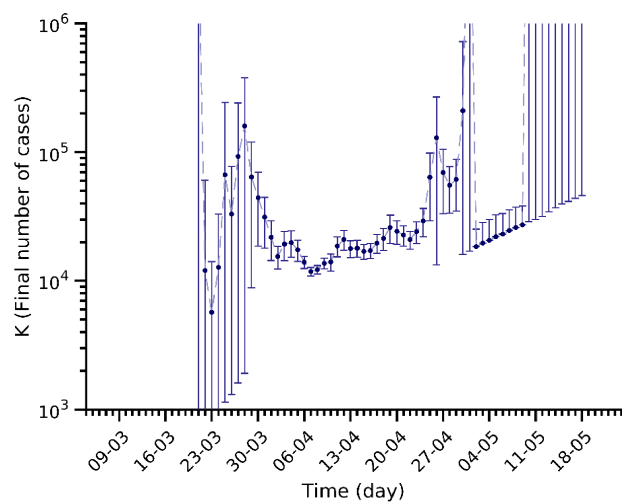
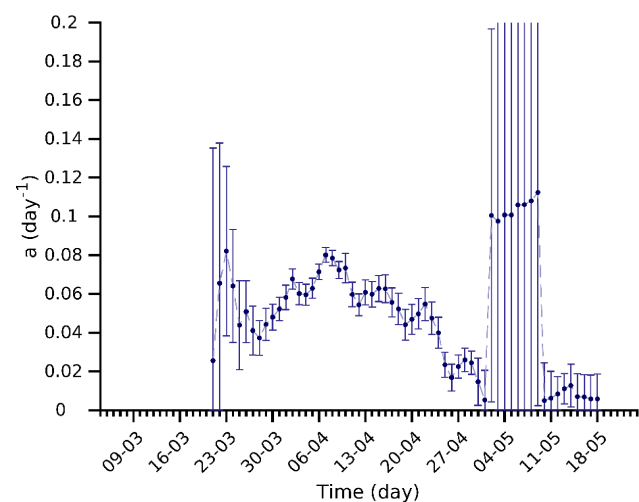
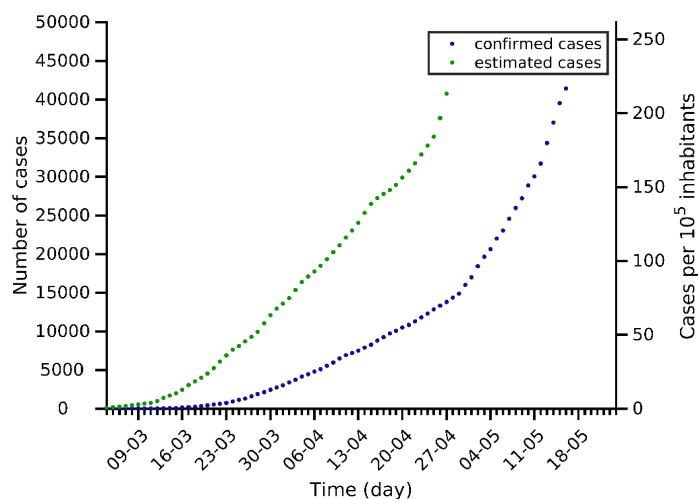
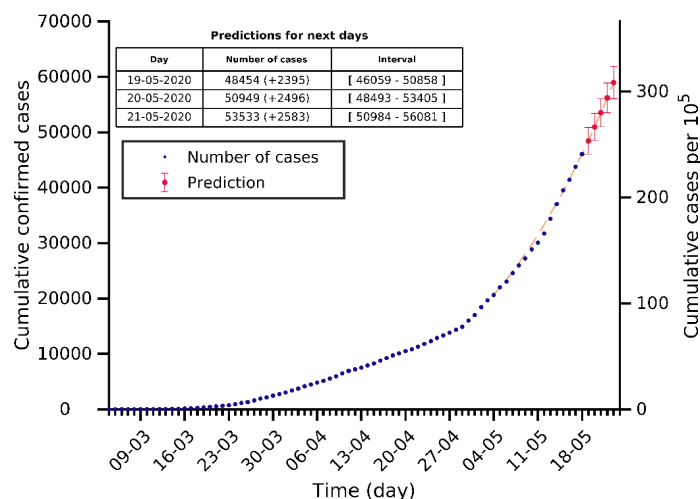
Canada 18-05-2020. Population: 37.7M. Current cumulated incidence: 207/10⁵



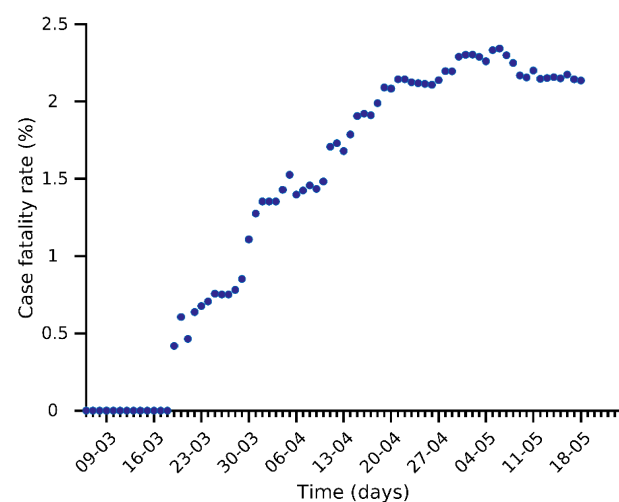
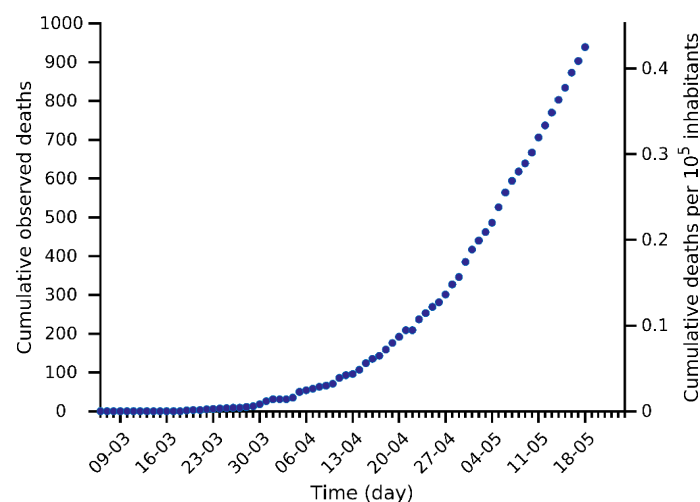
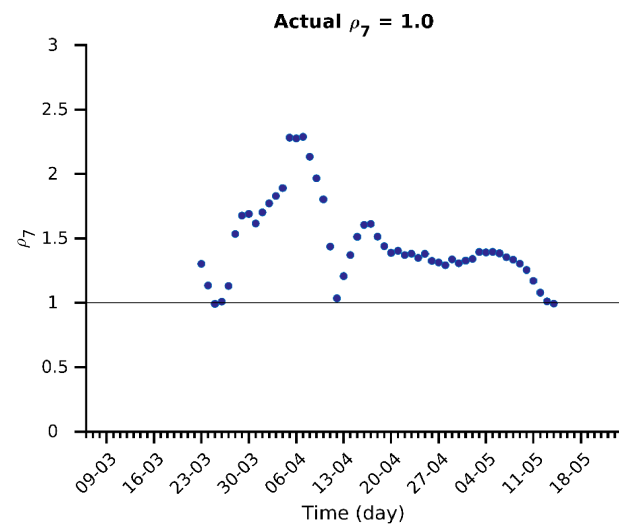
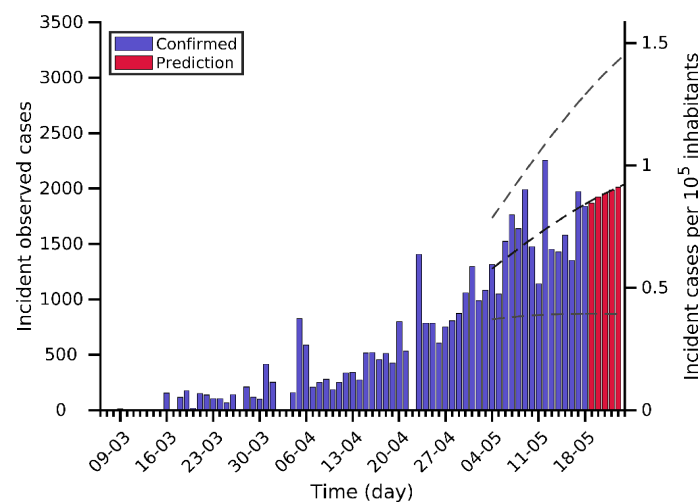
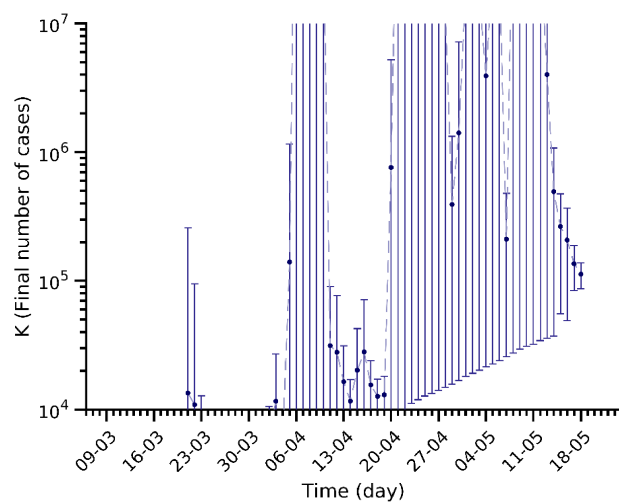
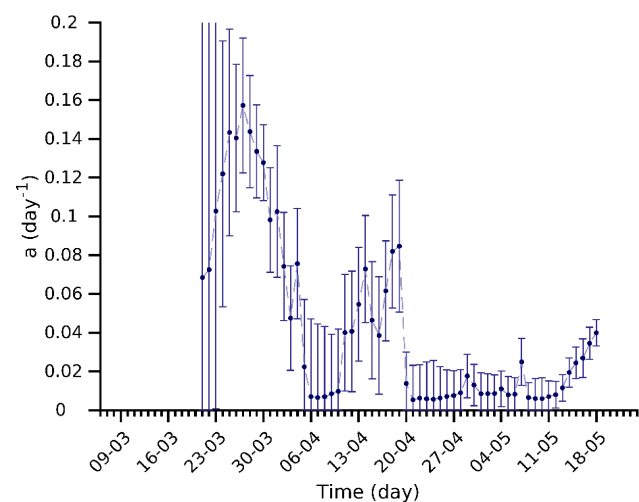
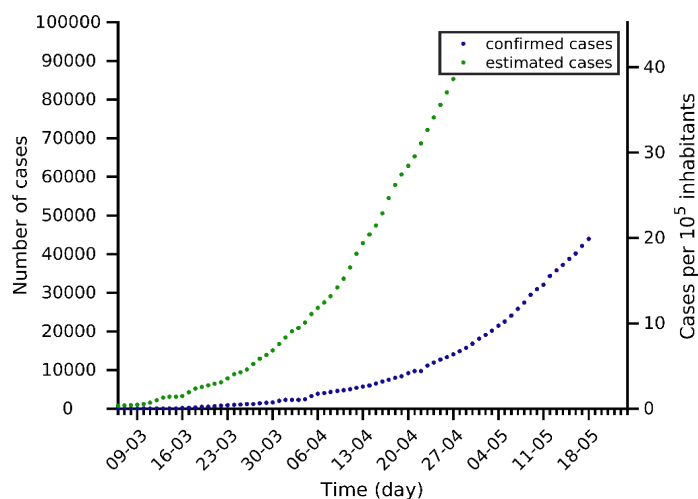
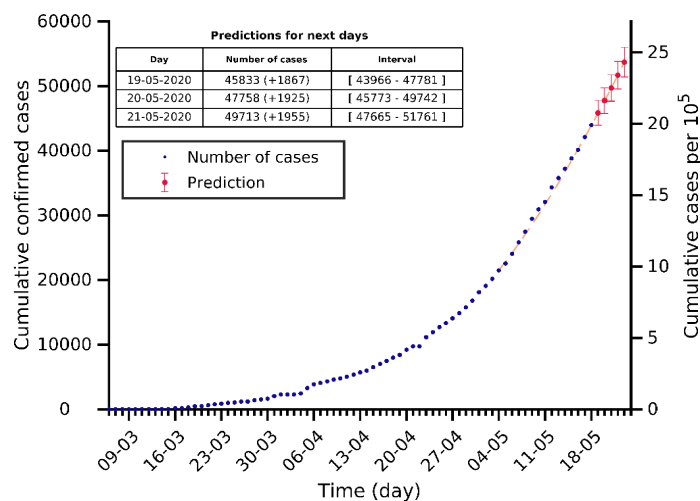
Mexico 18-05-2020. Population: 128.9M. Current cumulated incidence: 40/10⁵



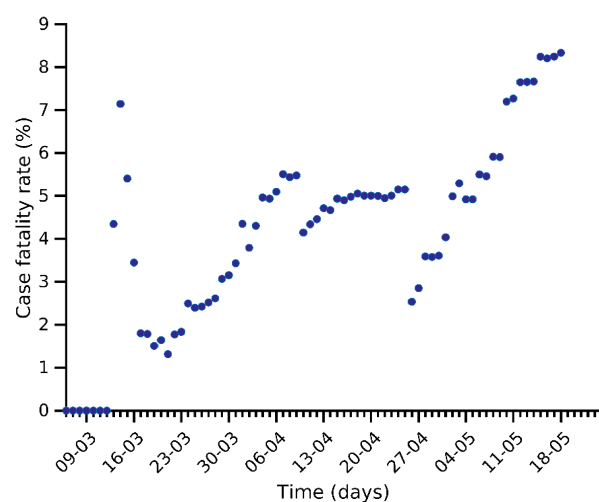
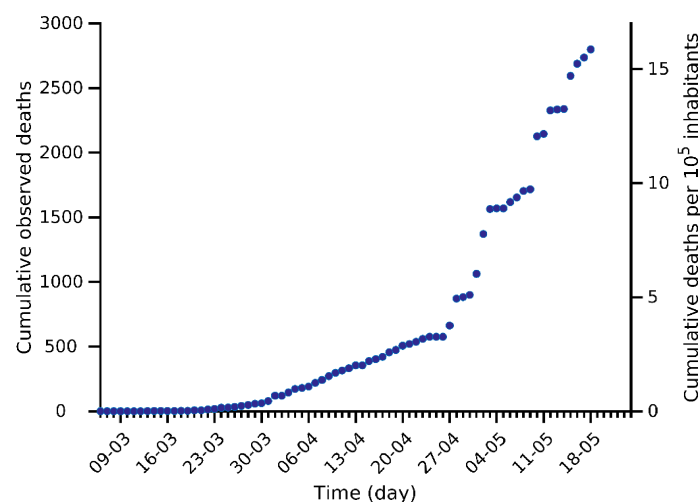
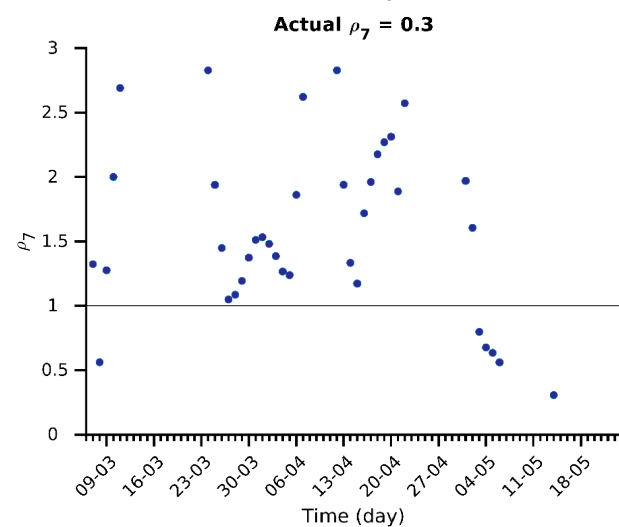
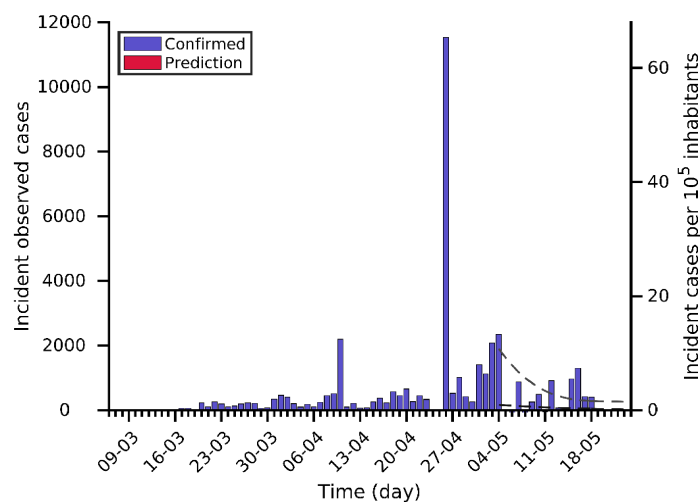
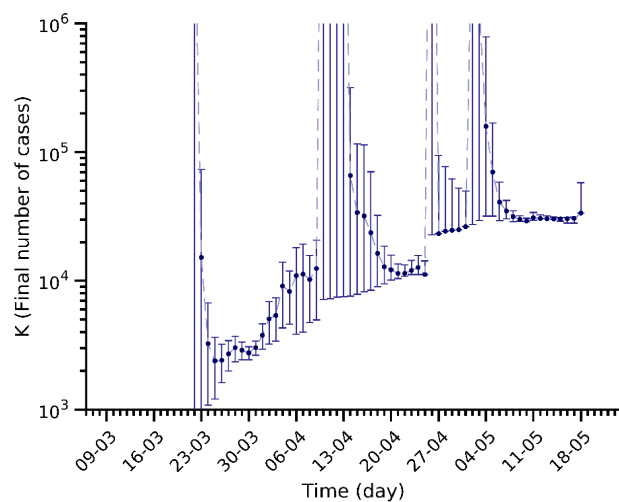
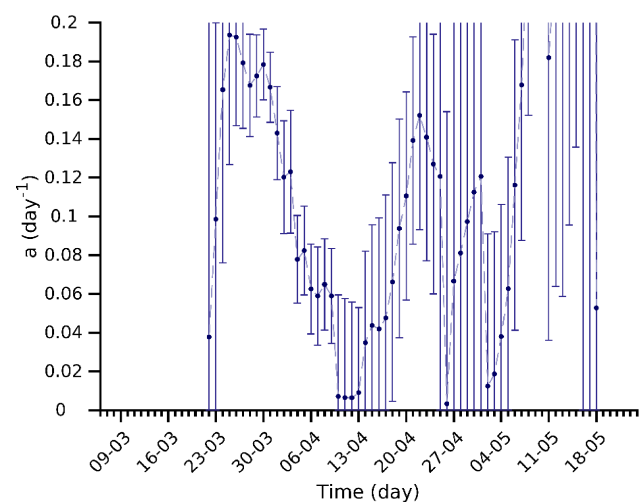
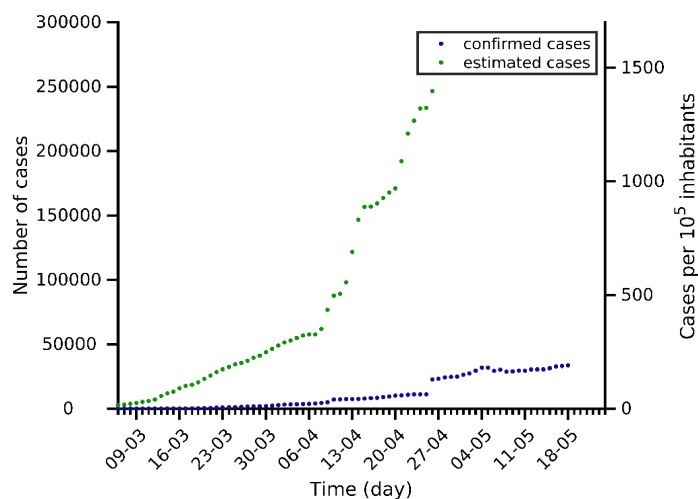
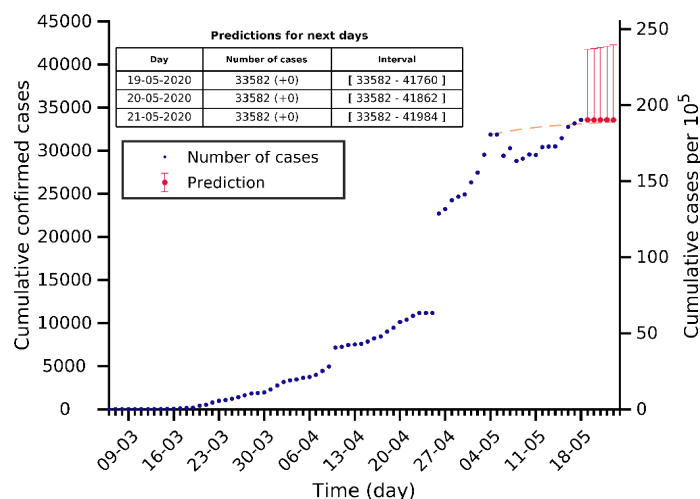
Chile 18-05-2020. Population: 19.1M. Current cumulated incidence: 241/10⁵



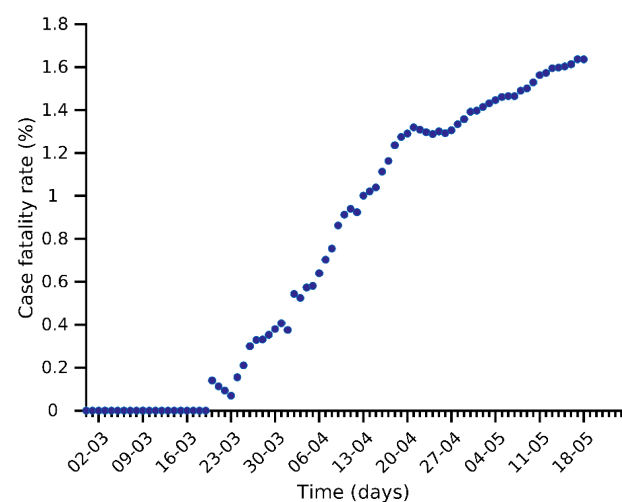
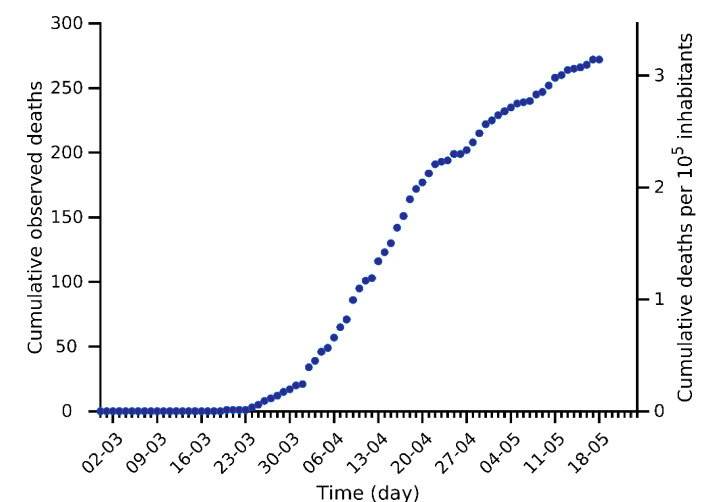
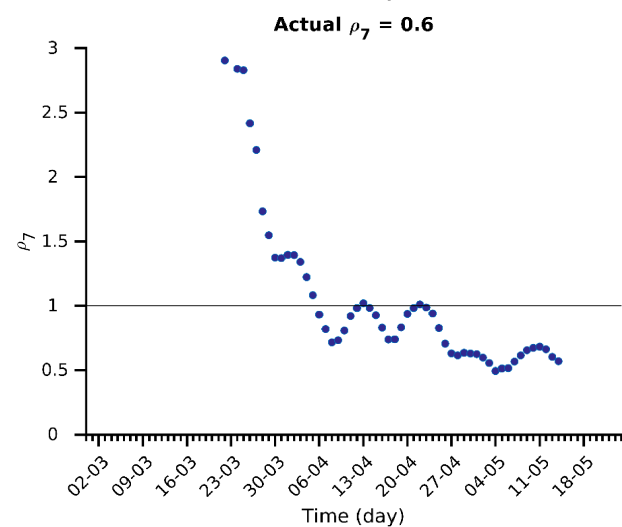
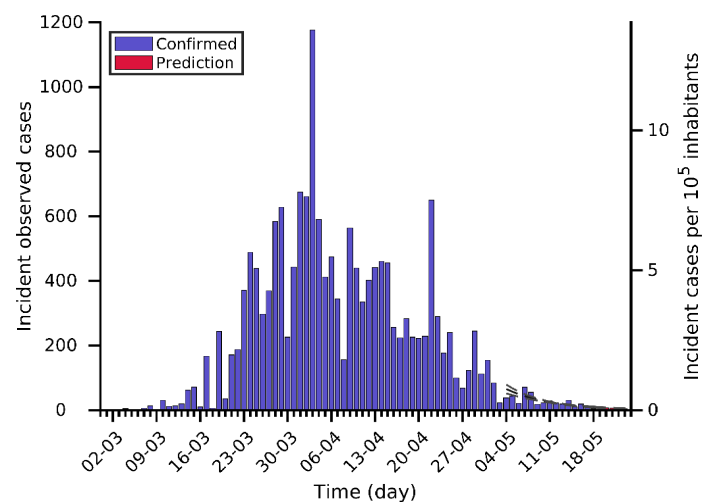
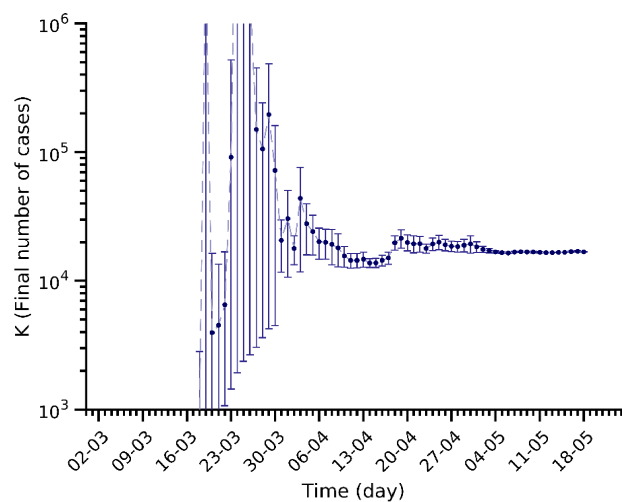
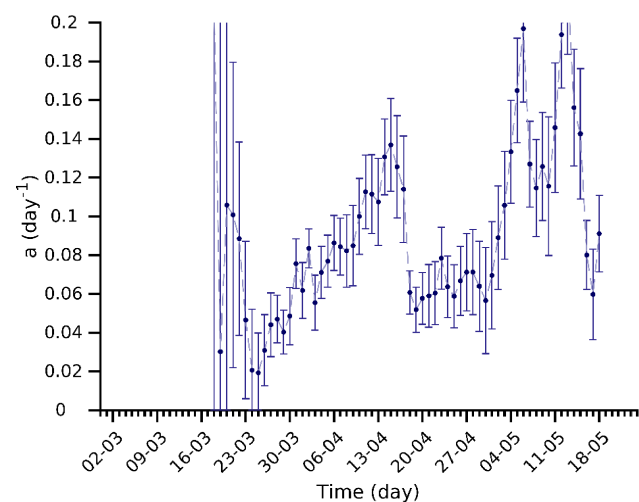
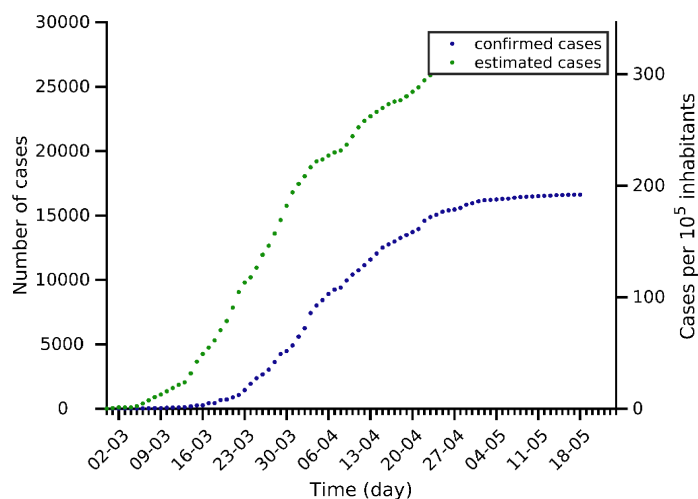
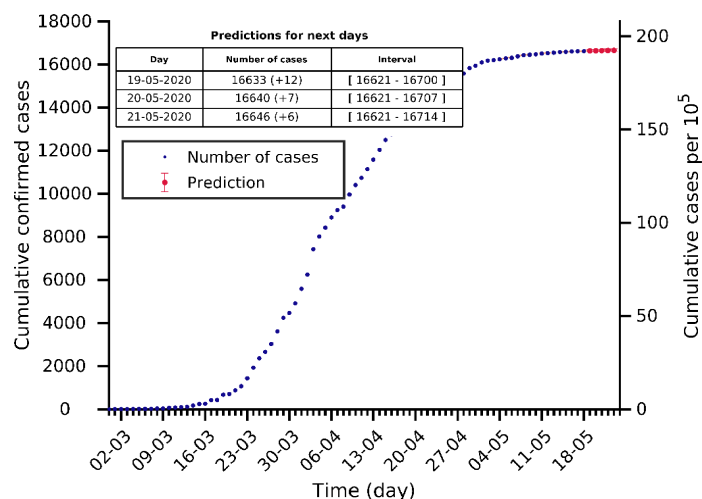
Pakistan 18-05-2020. Population: 220.9M. Current cumulated incidence: 20/10⁵



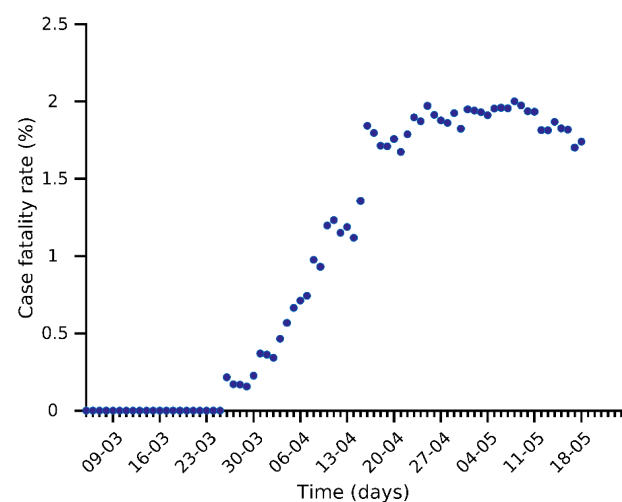
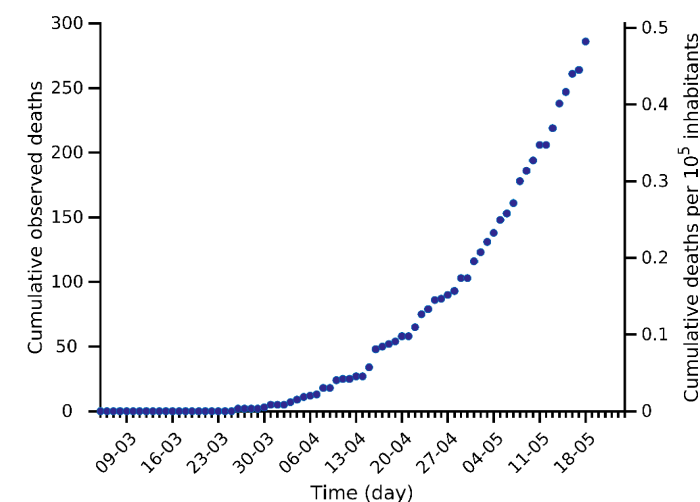
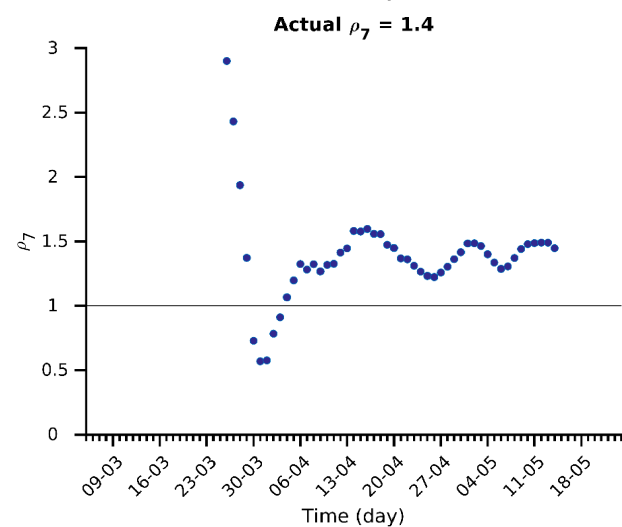
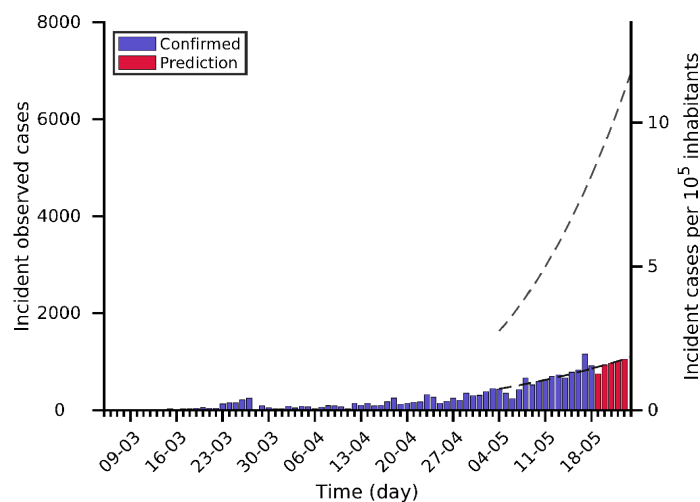
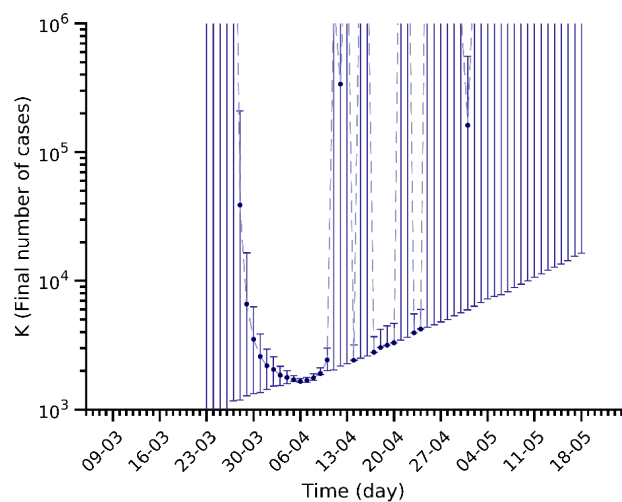
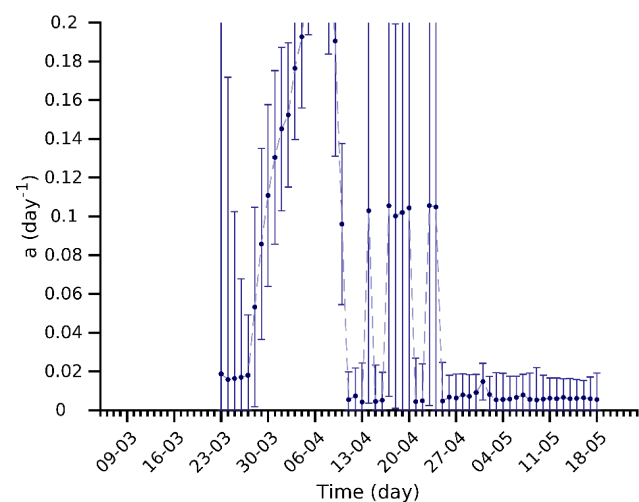
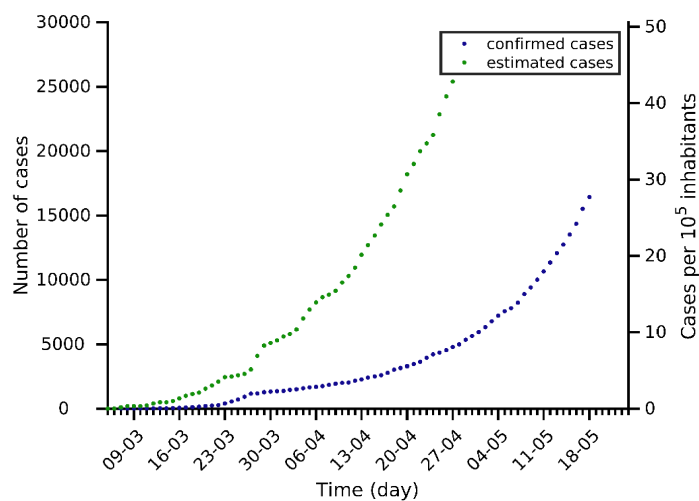
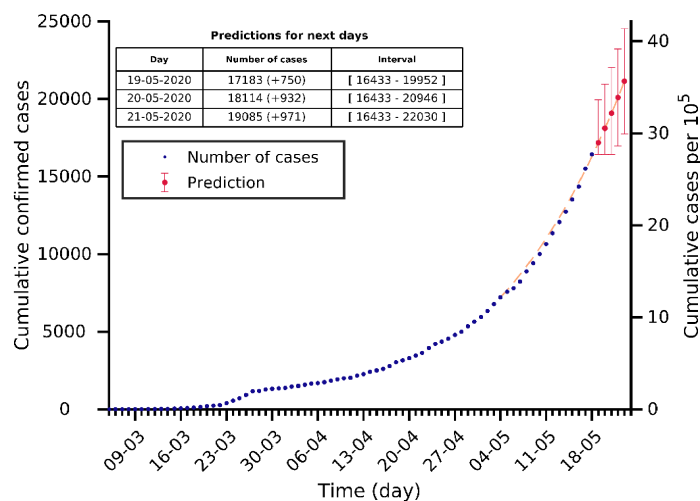
Ecuador 18-05-2020. Population: 17.6M. Current cumulated incidence: 190/10⁵



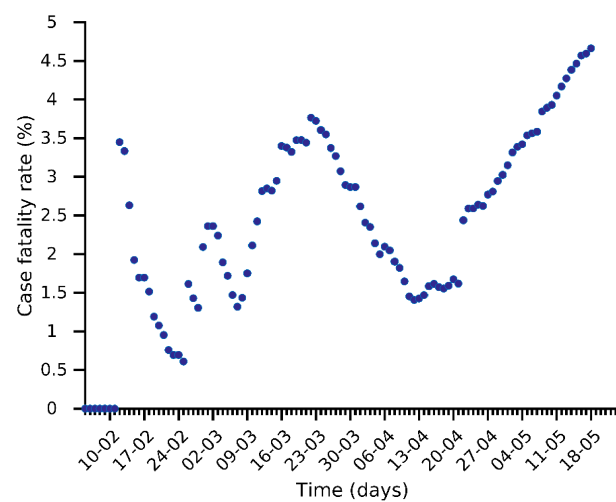
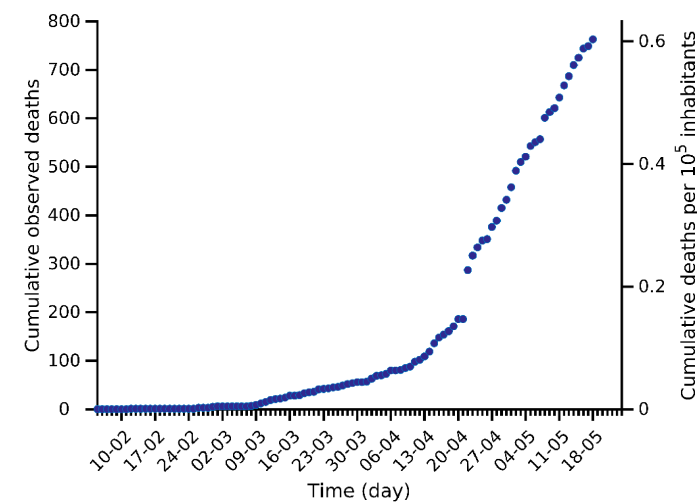
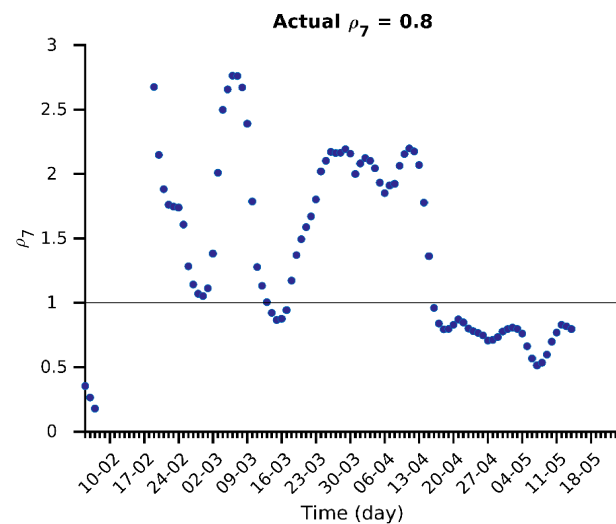
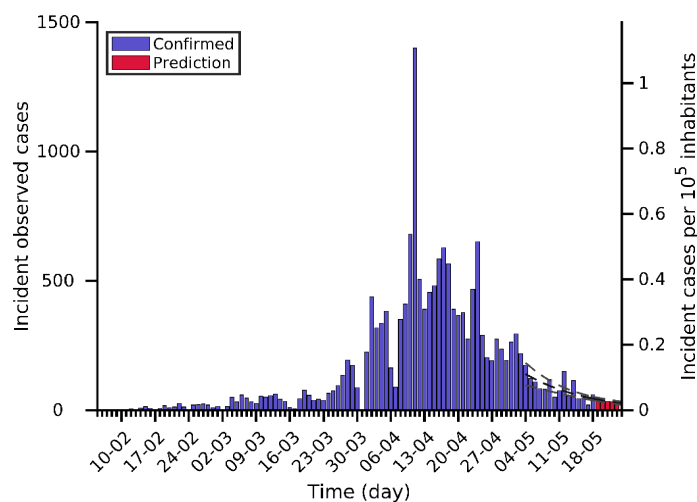
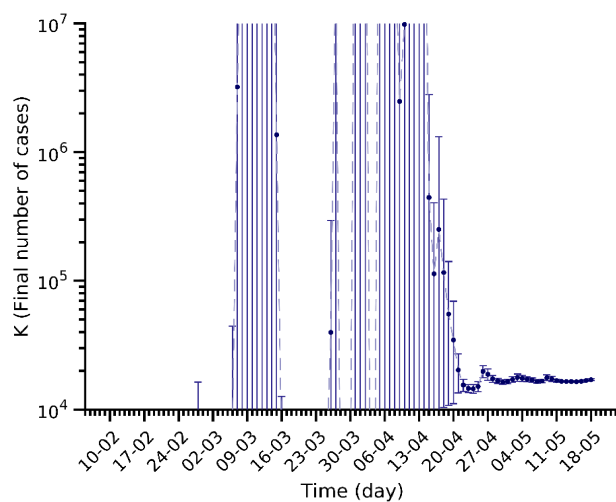
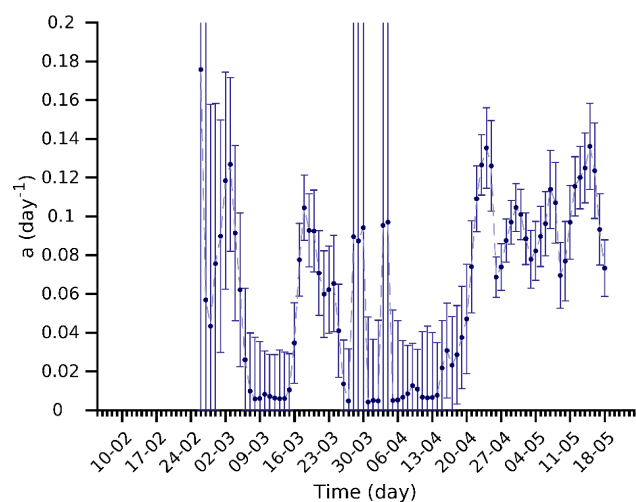
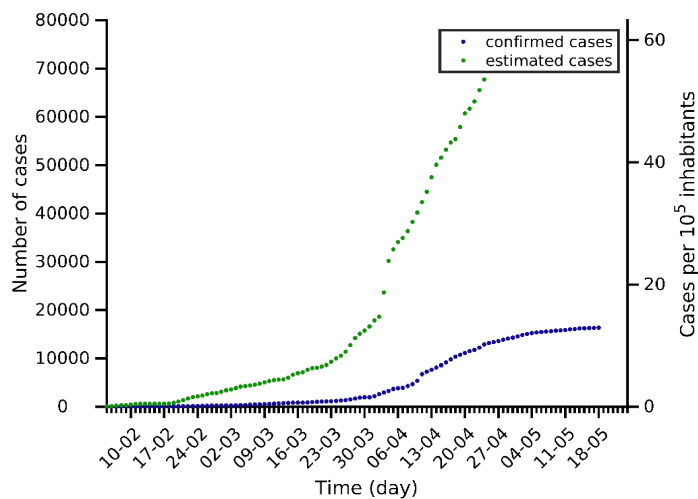
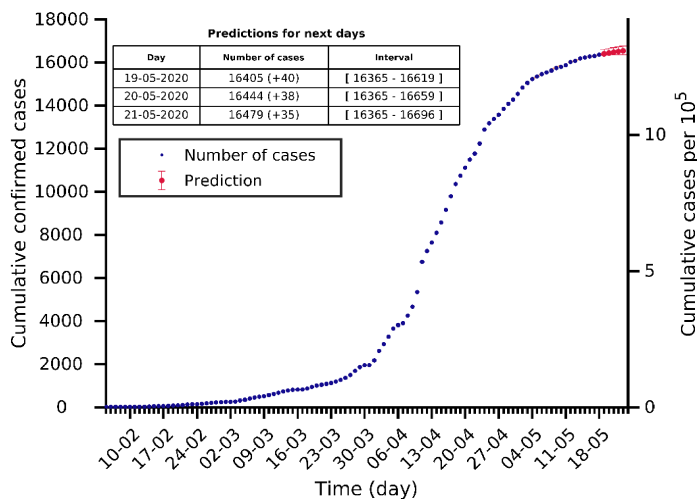
Israel 18-05-2020. Population: 8.7M. Current cumulated incidence: 192/10⁵



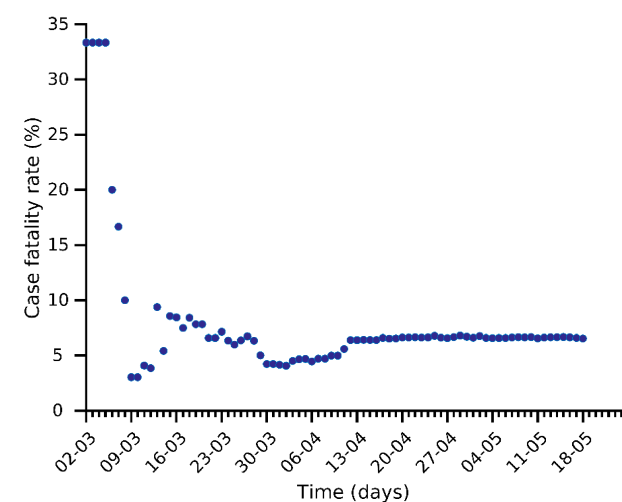
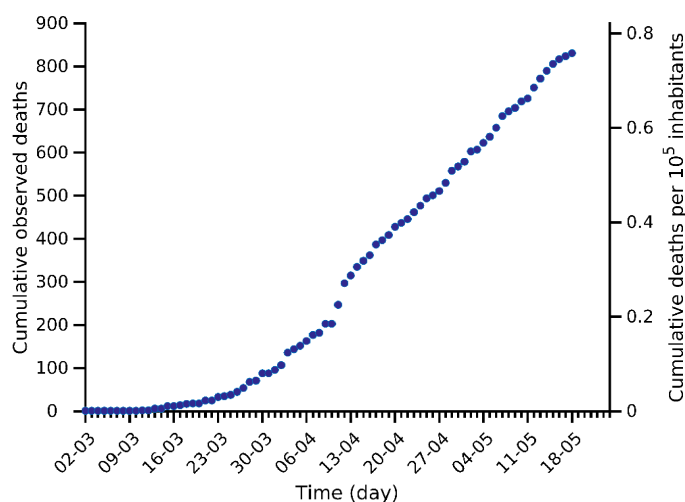
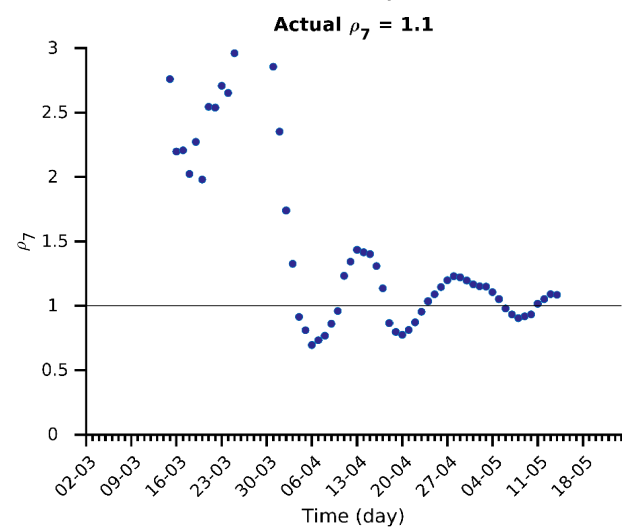
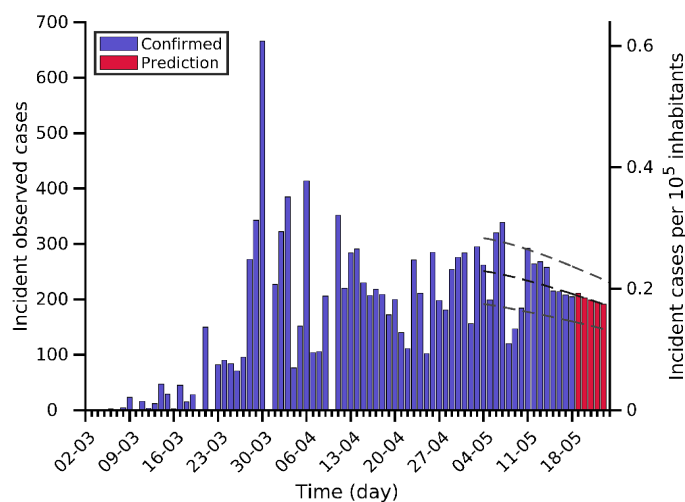
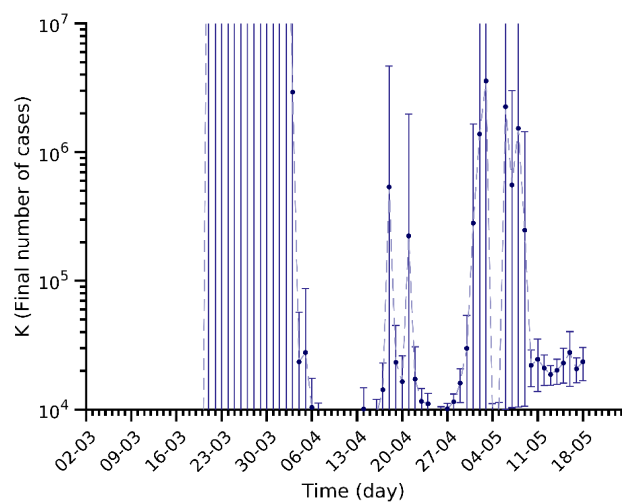
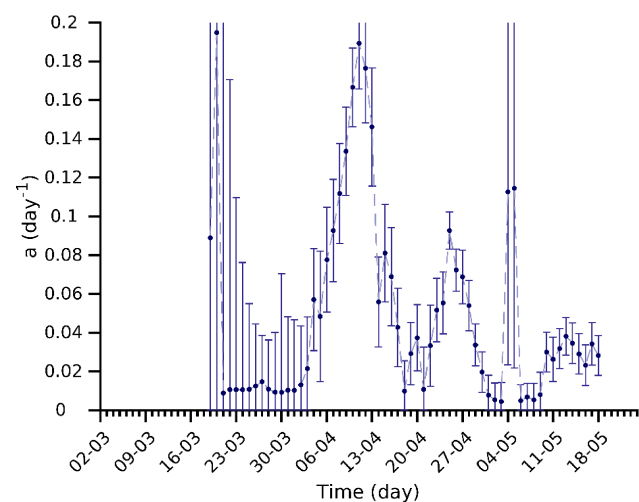
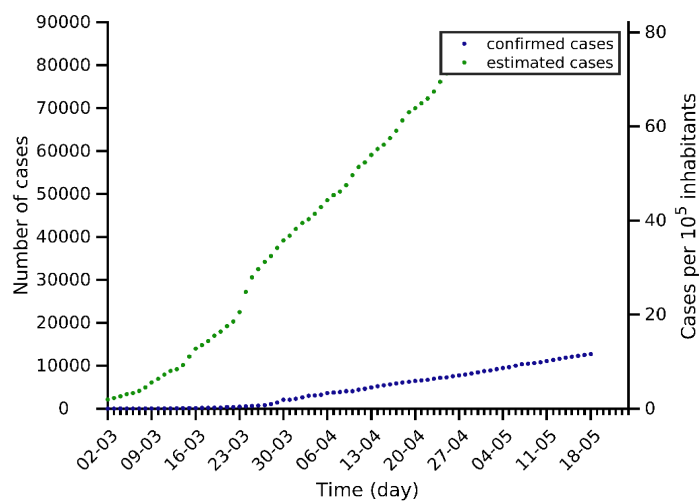
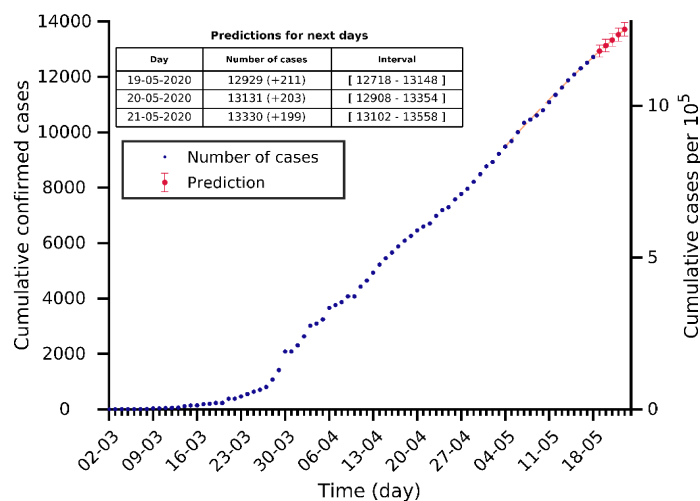
South Africa 18-05-2020. Population: 59.3M. Current cumulated incidence: 28/10⁵



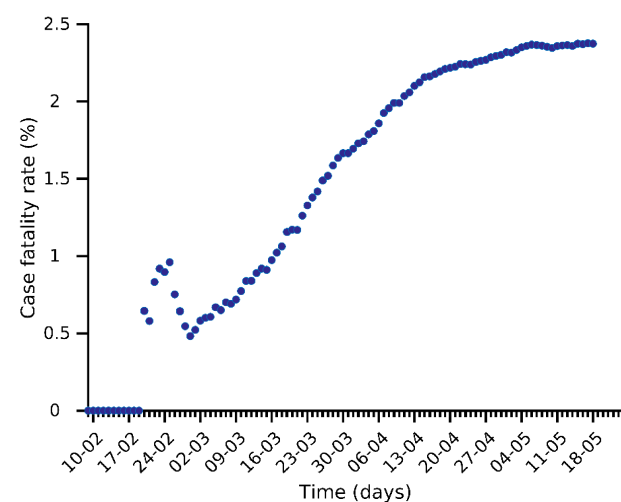
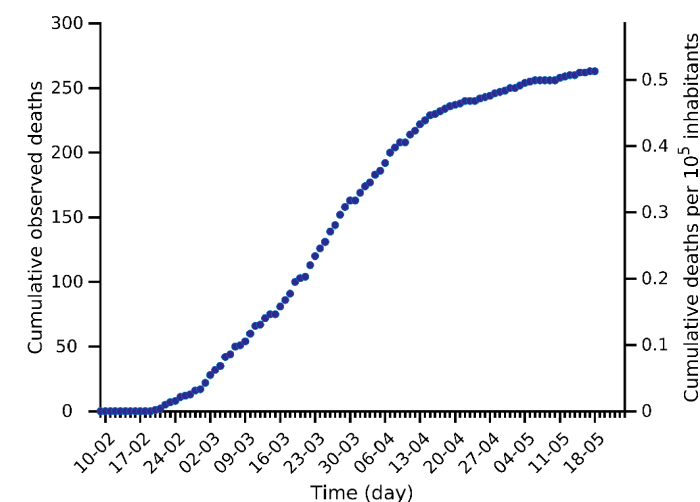
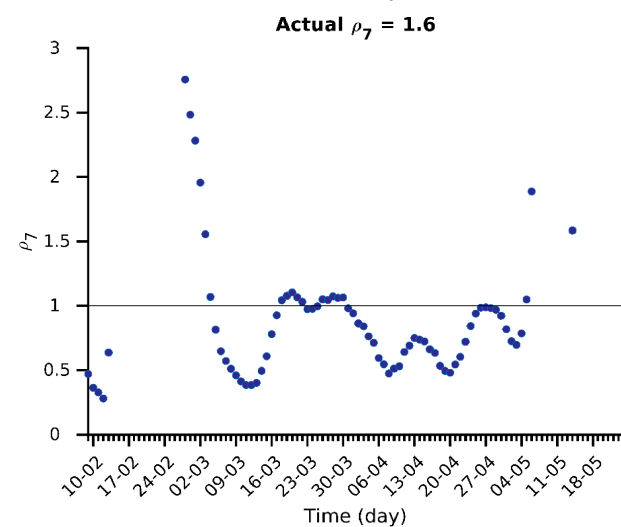
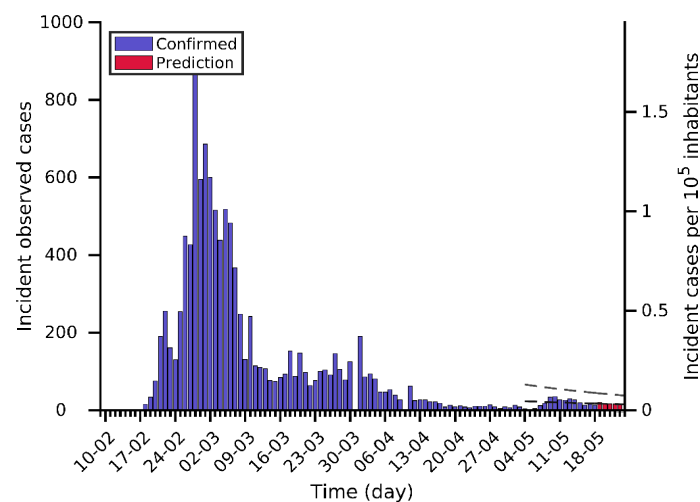
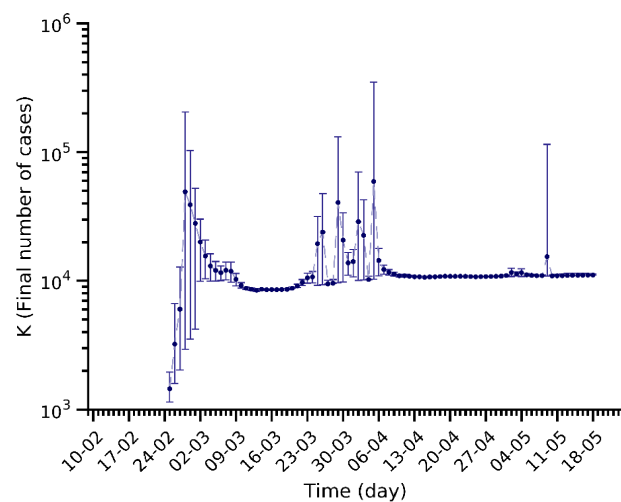
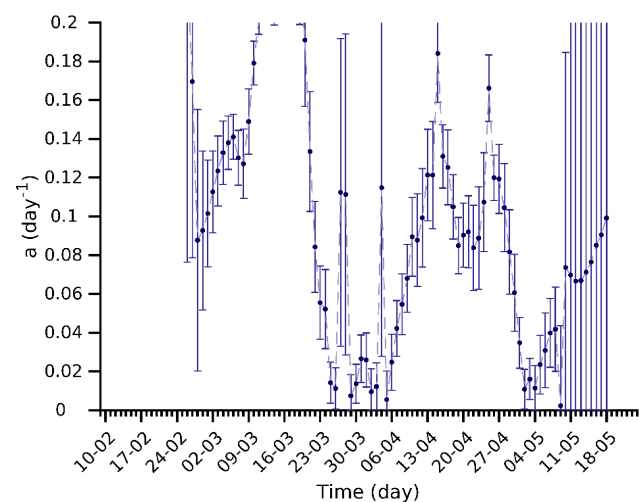
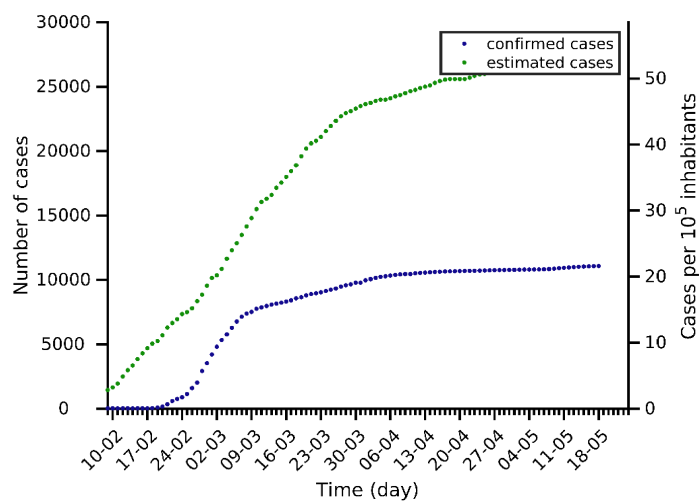
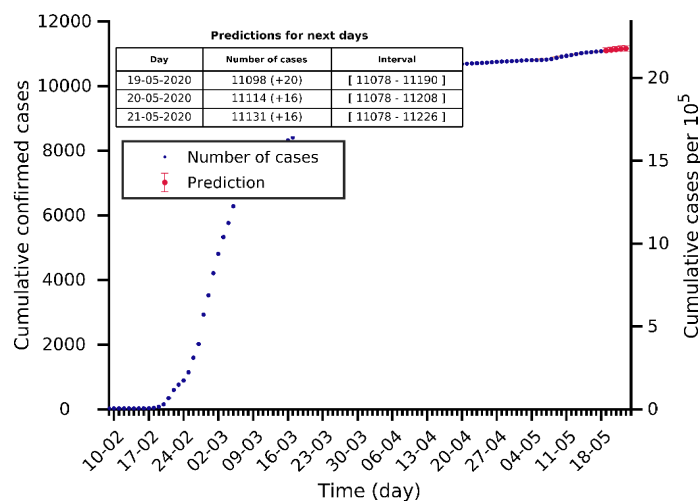
Japan 18-05-2020. Population: 126.5M. Current cumulated incidence: 13/10⁵



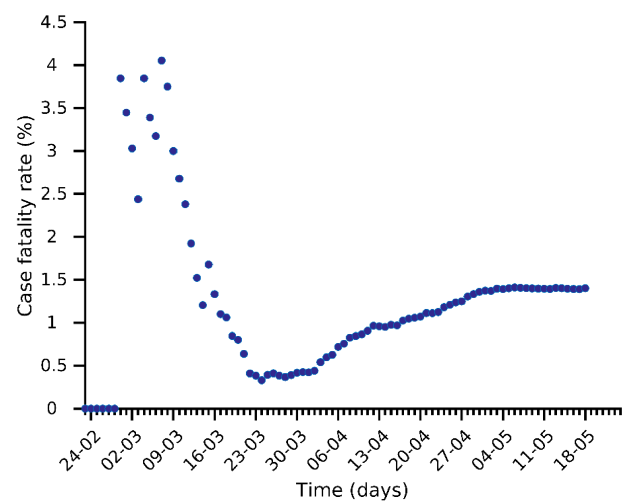
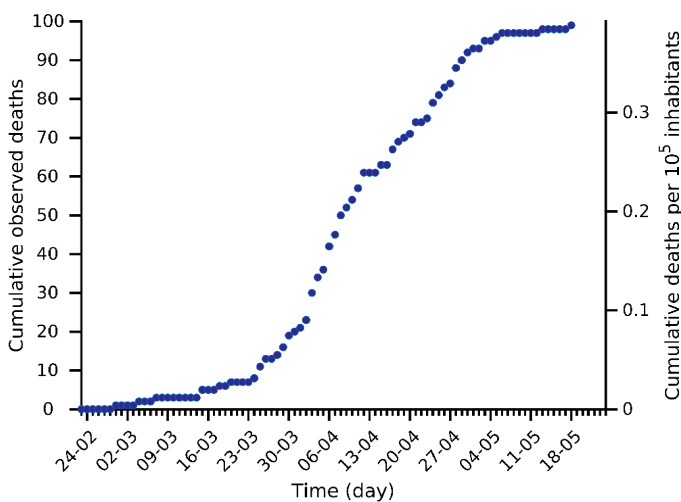
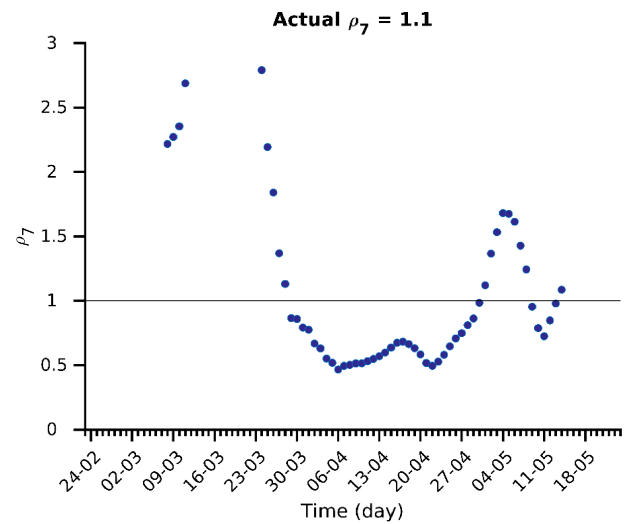
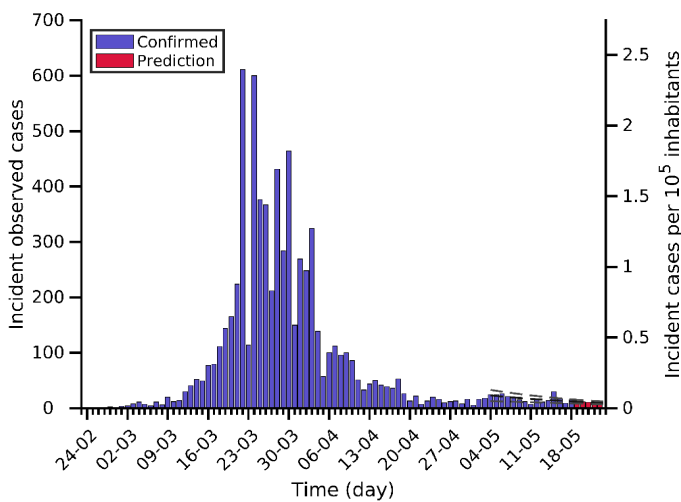
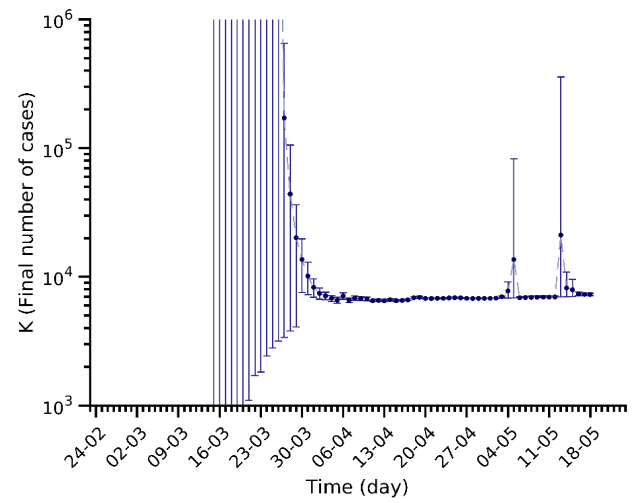
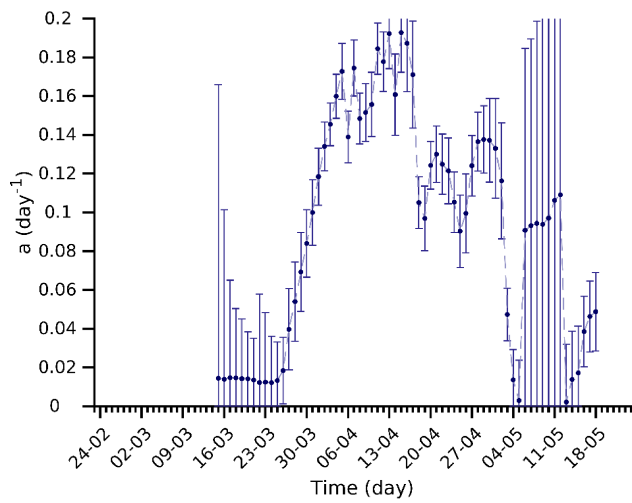
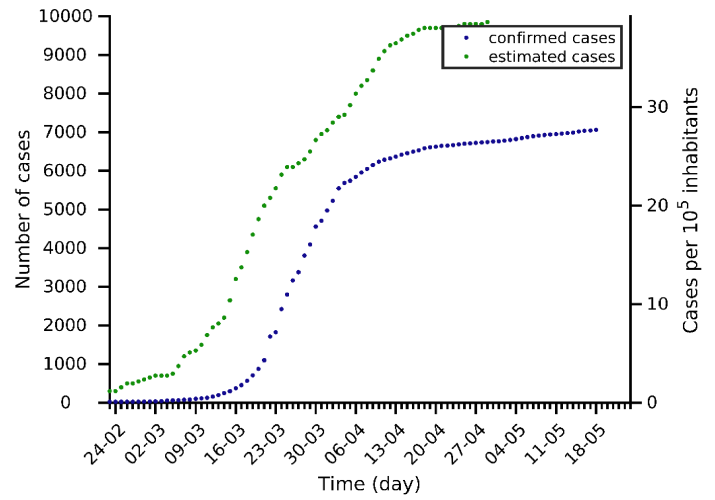
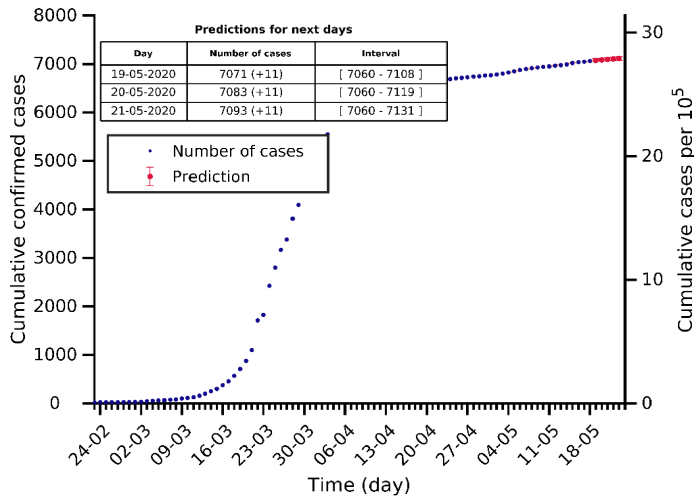
Philippines 18-05-2020. Population: 109.6M. Current cumulated incidence: 12/10⁵



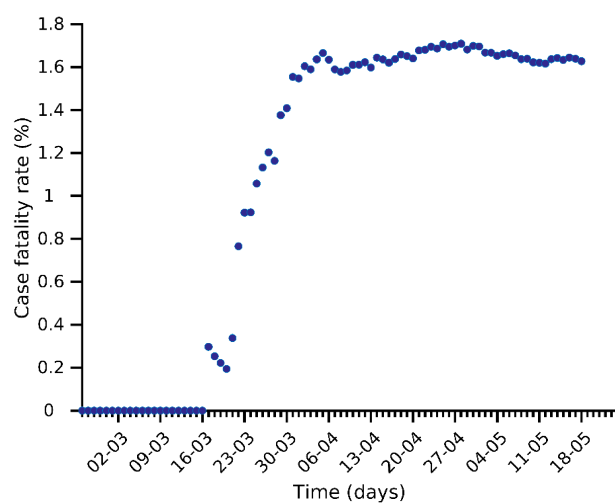
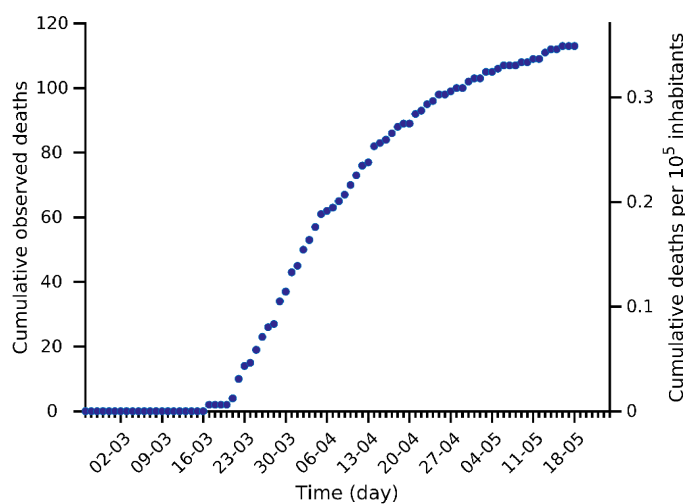
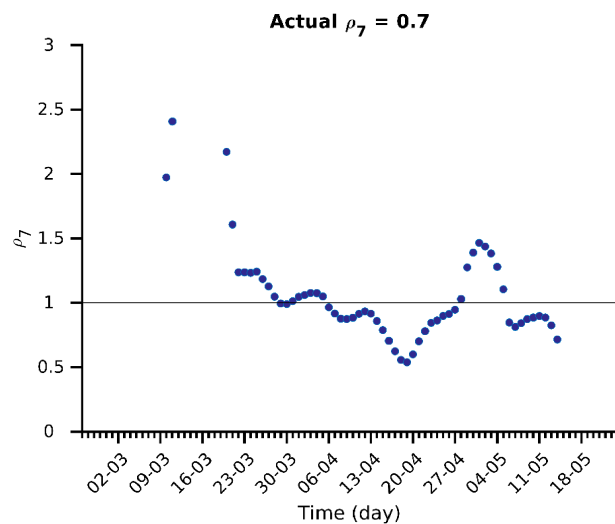
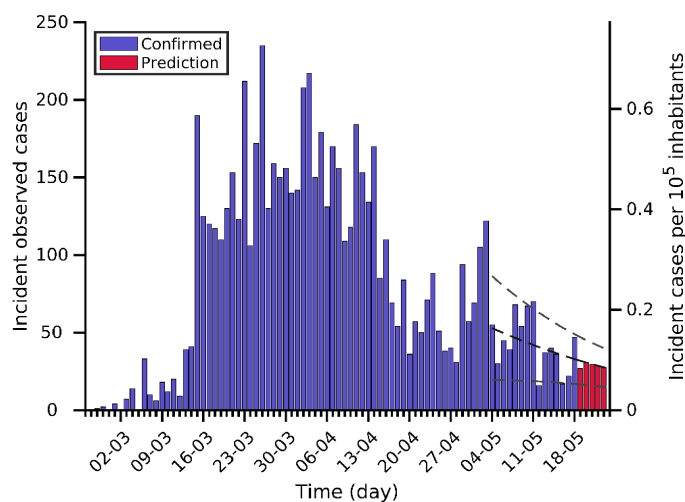
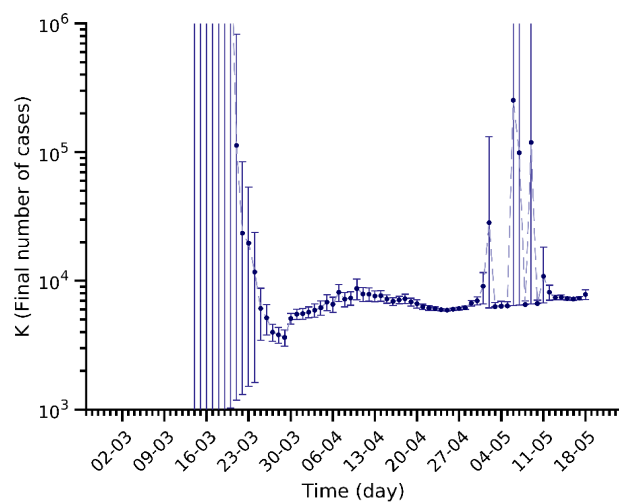
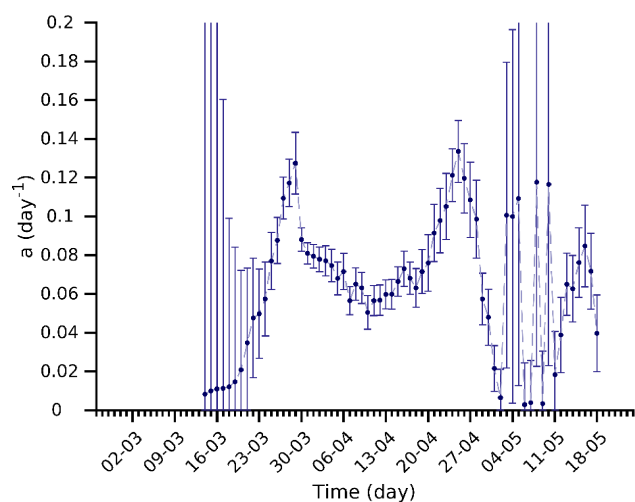
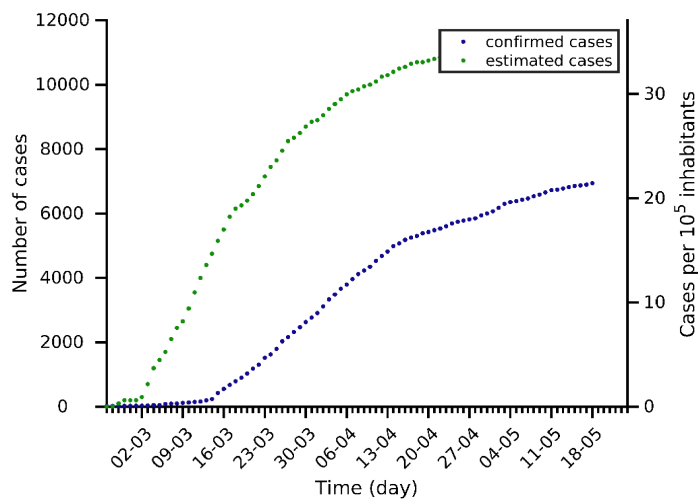
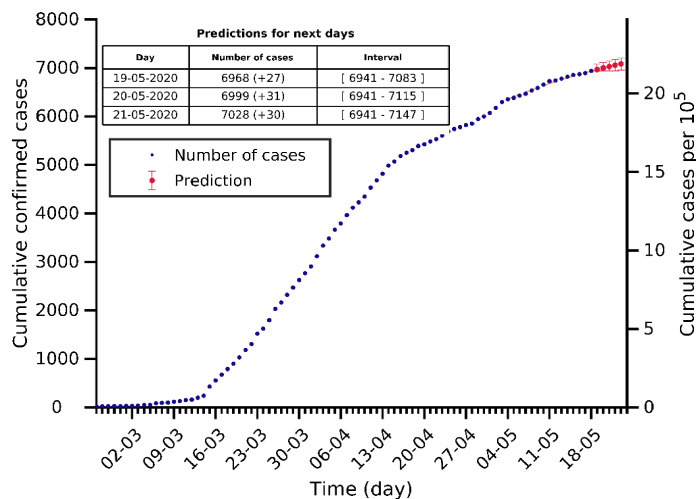
South Korea 18-05-2020. Population: 51.3M. Current cumulated incidence: 22/10⁵



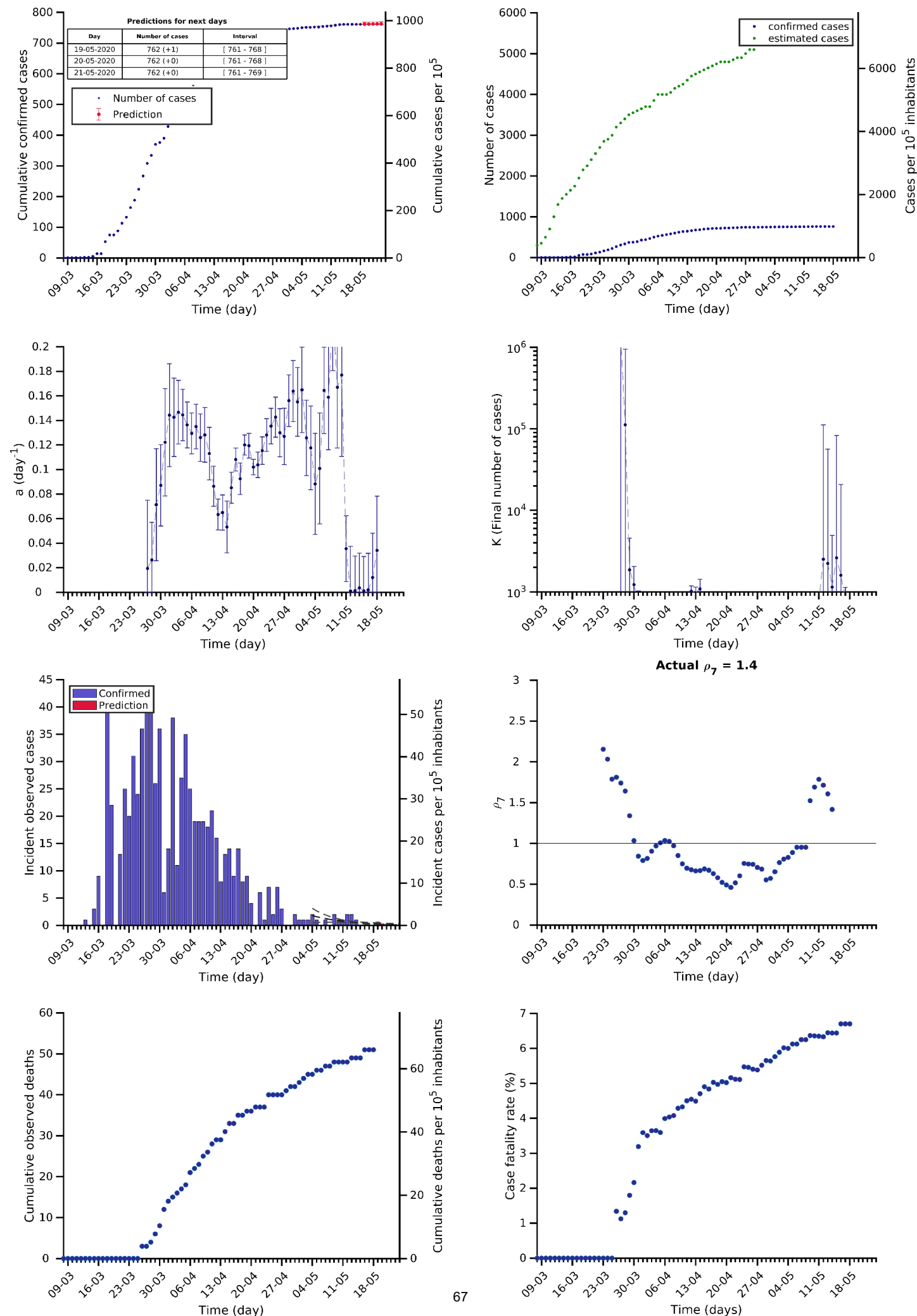
Australia 18-05-2020. Population: 25.5M. Current cumulated incidence: 28/10⁵



Malaysia 18-05-2020. Population: 32.4M. Current cumulated incidence: 21/10⁵



Andorra 18-05-2020. Population: 0.1M. Current cumulated incidence: 985/10⁵

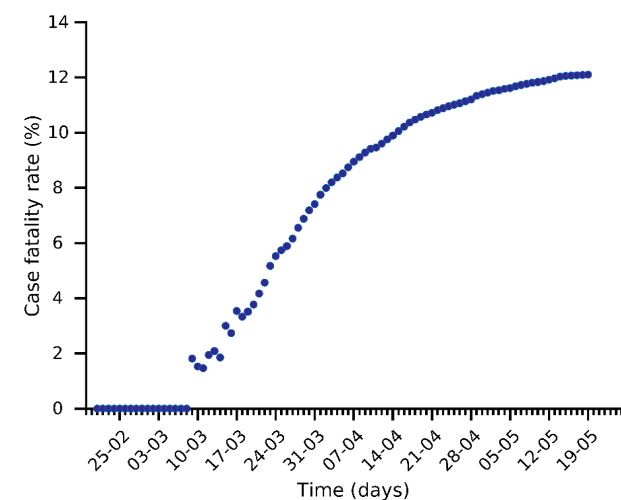
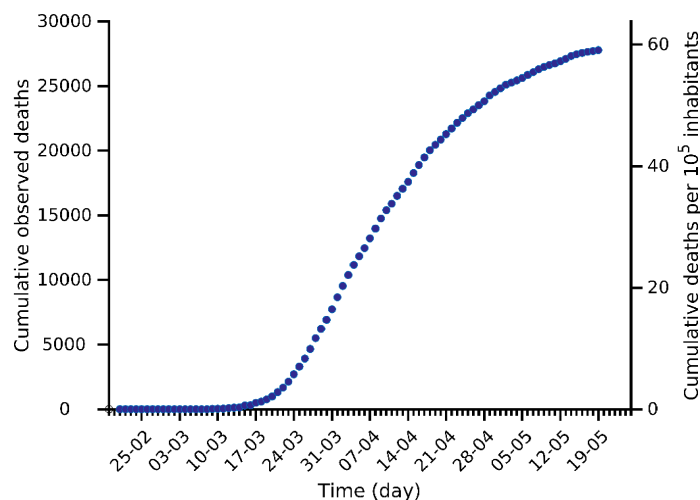
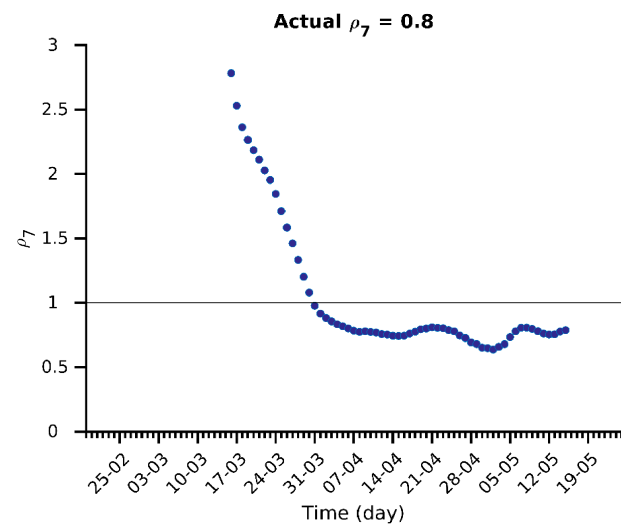
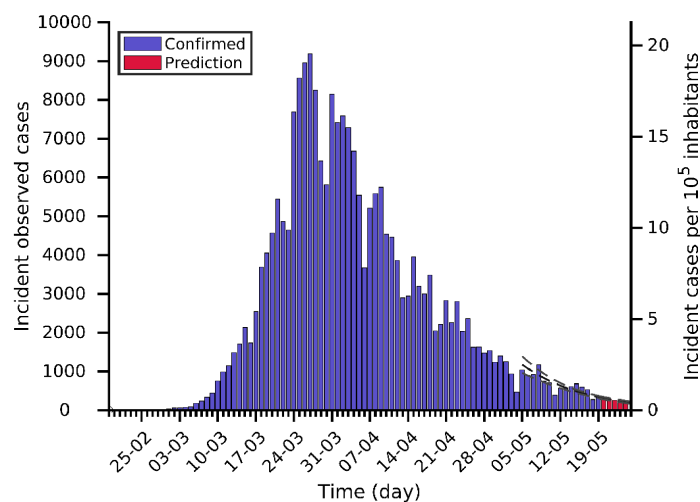
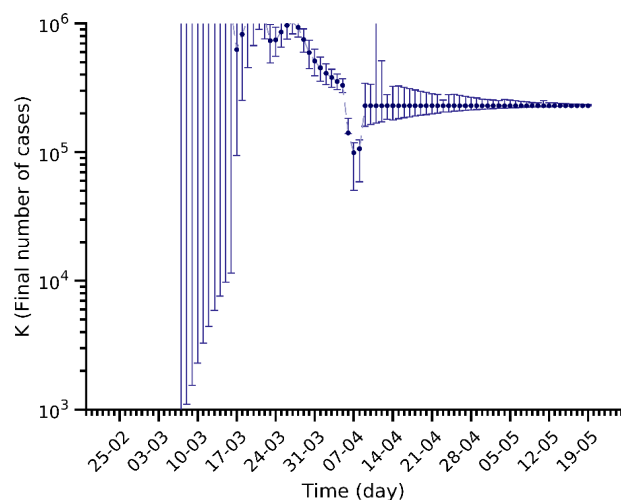
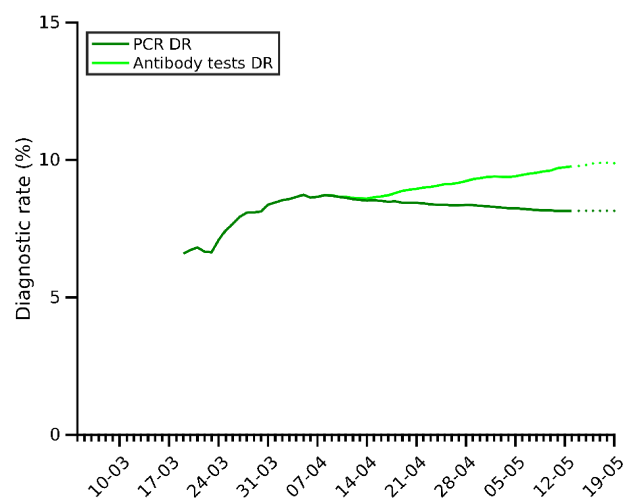
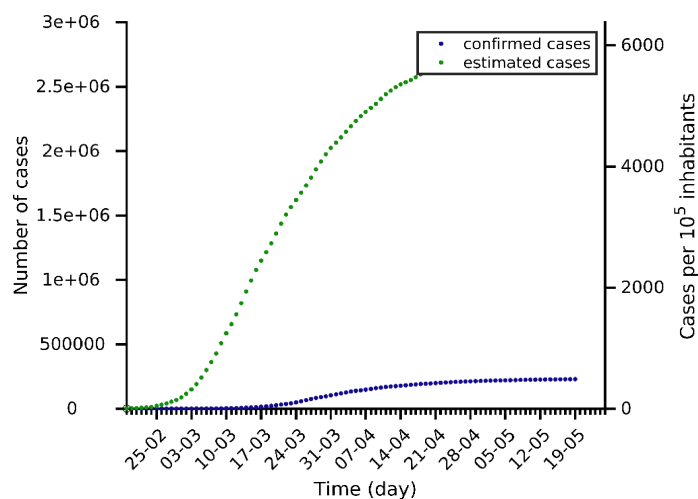
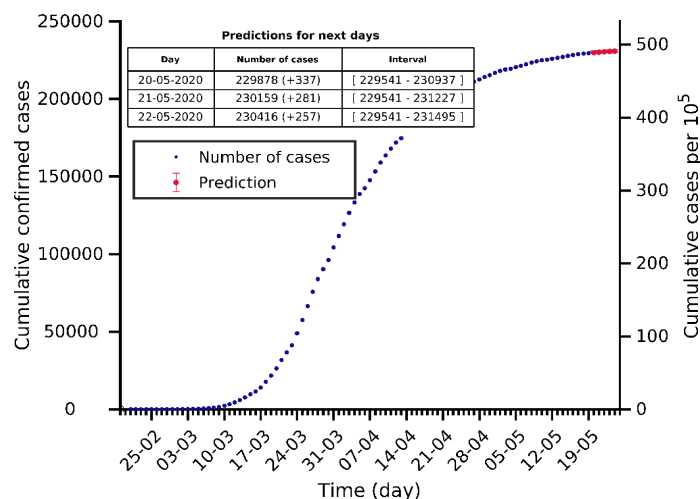


(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

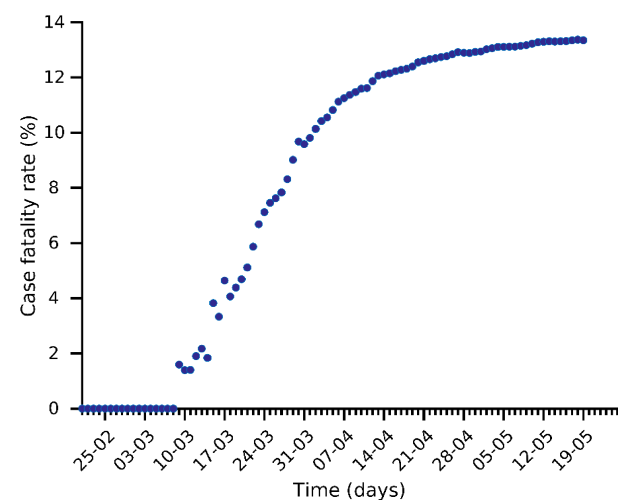
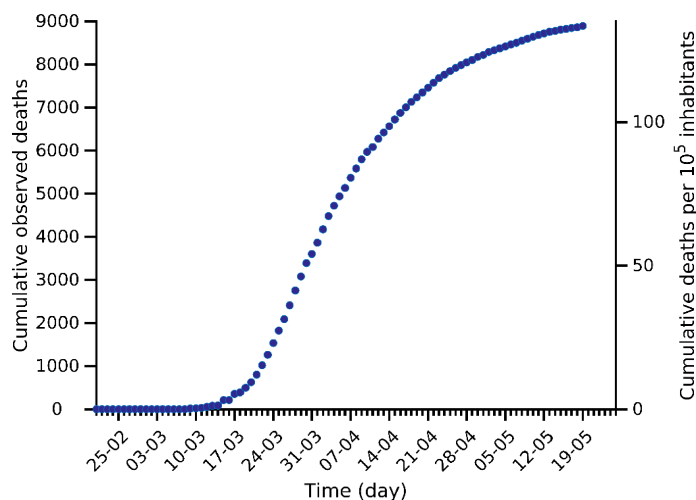
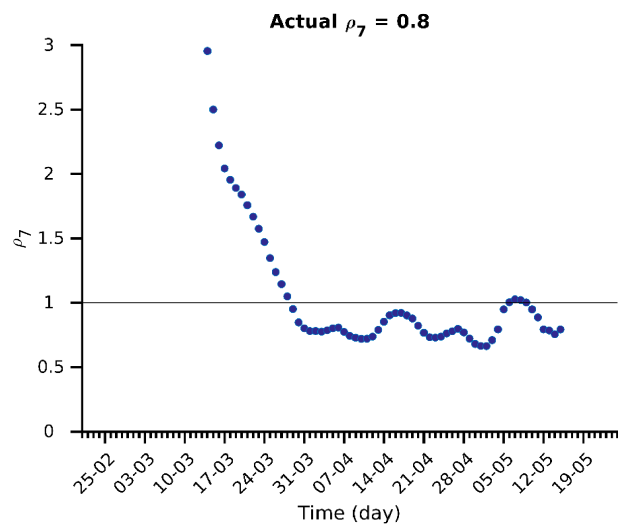
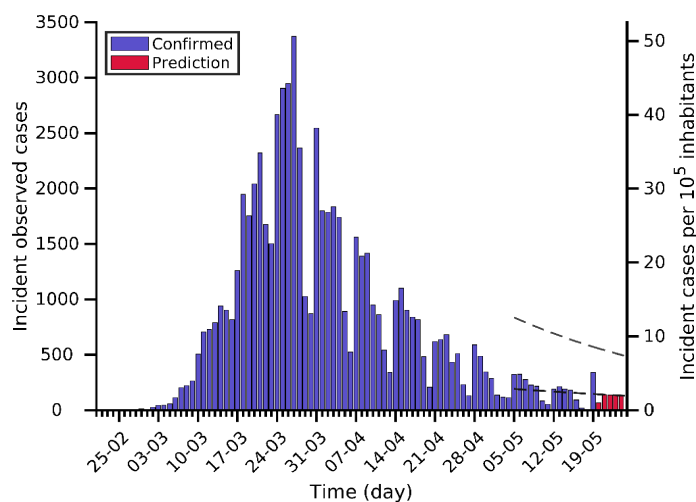
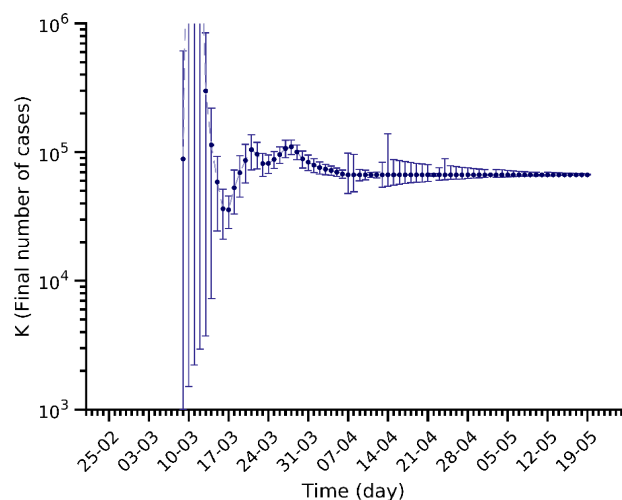
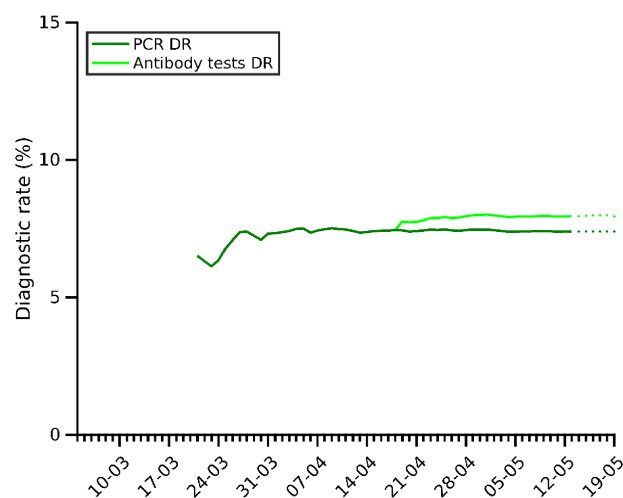
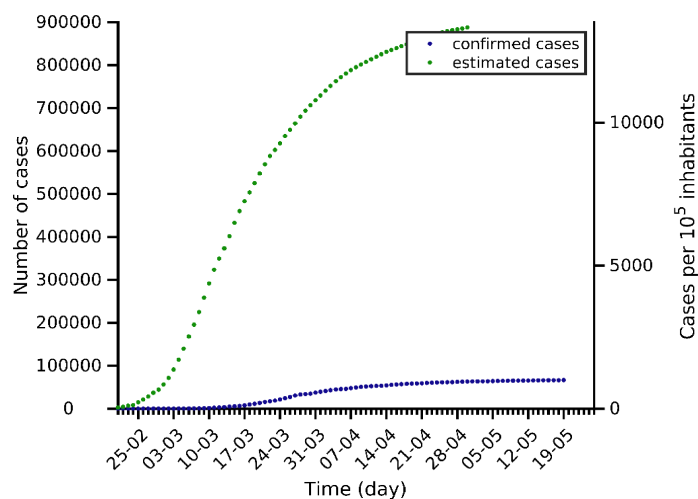
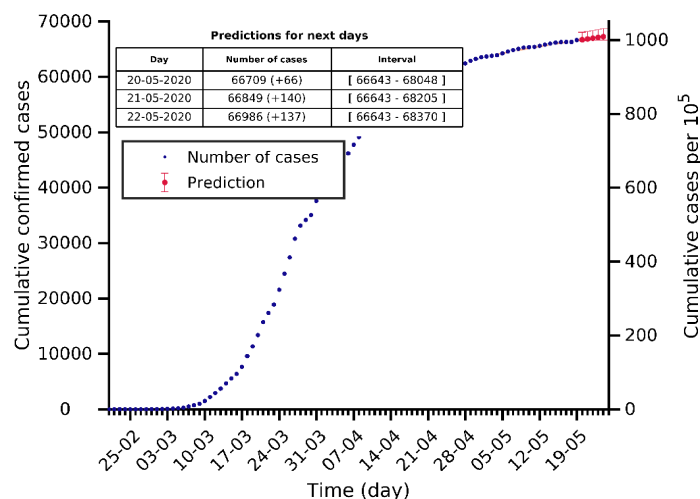
WARNING 1: Data from Catalunya and Spain are provisional, pending on the indication to locate 2715 old cases.

WARNING 2: These reports have been elaborated without consolidated dataserries from ISCiii, so the results are provisional (data published by Health Ministry).

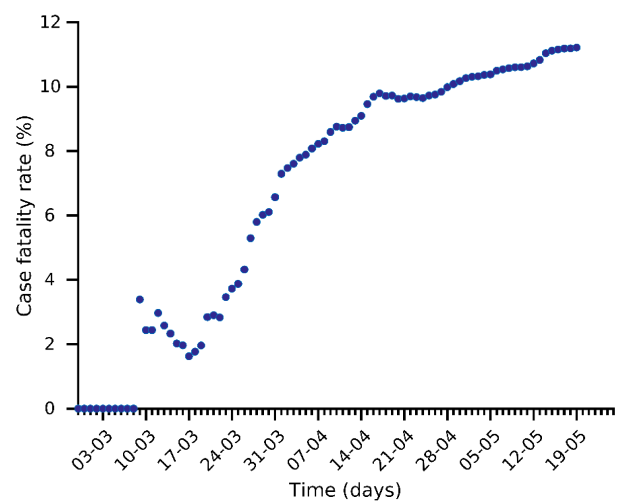
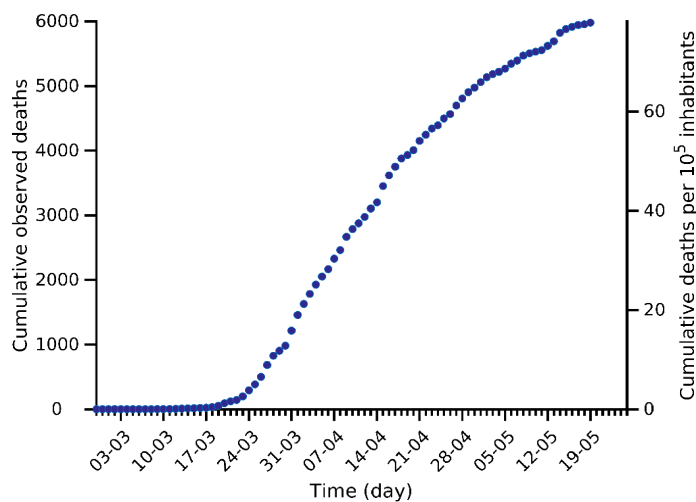
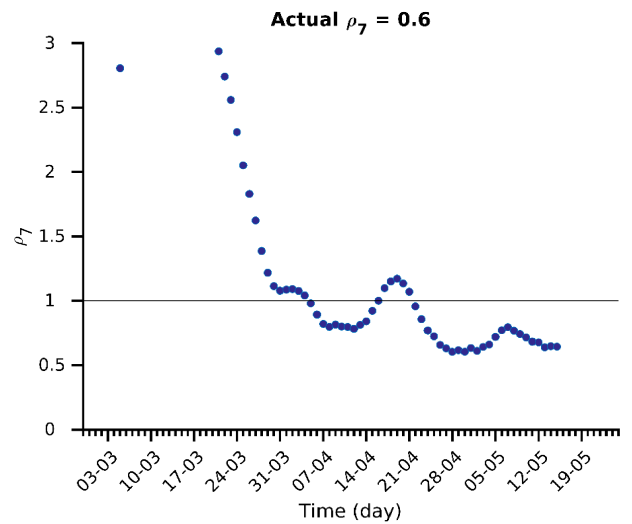
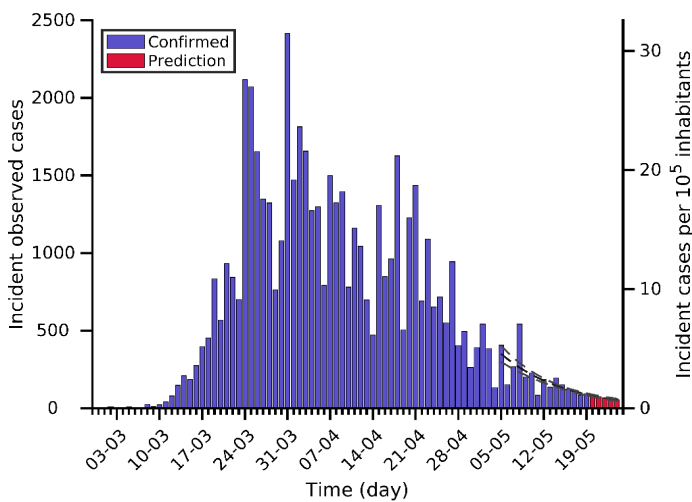
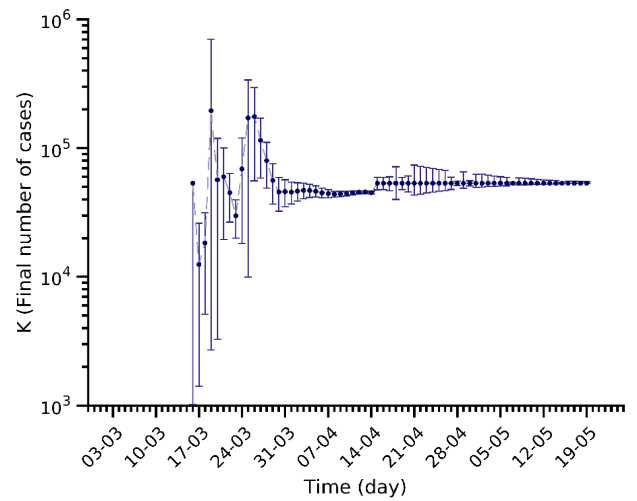
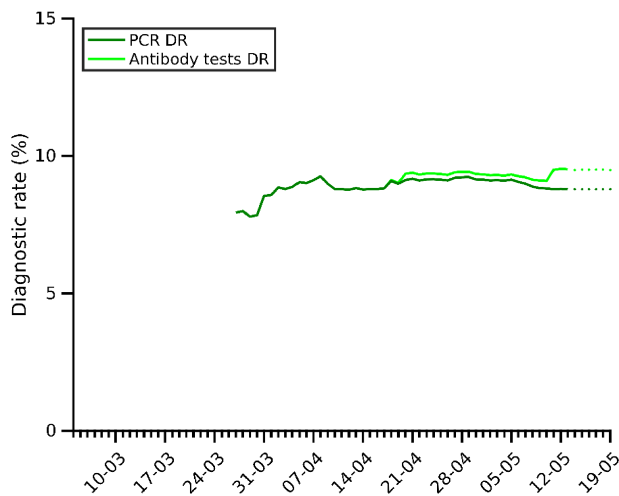
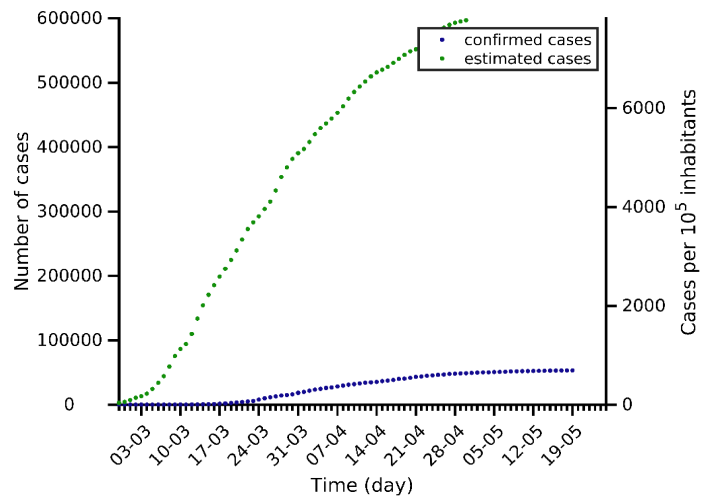
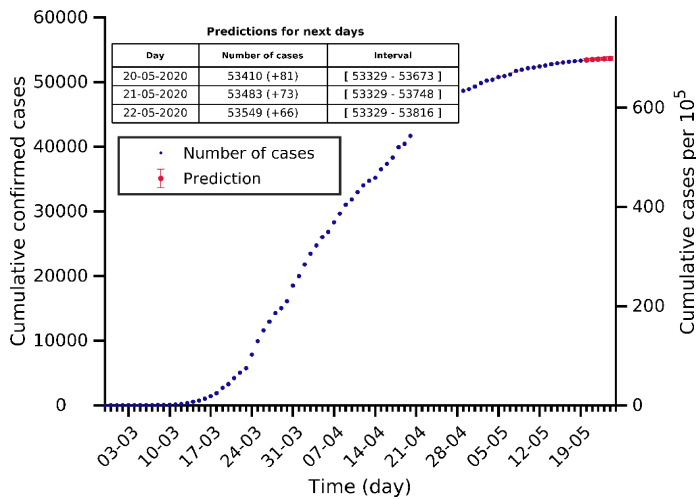
Spain 19-05-2020. Population: 47.0M. Current cumulated incidence: 488/10⁵



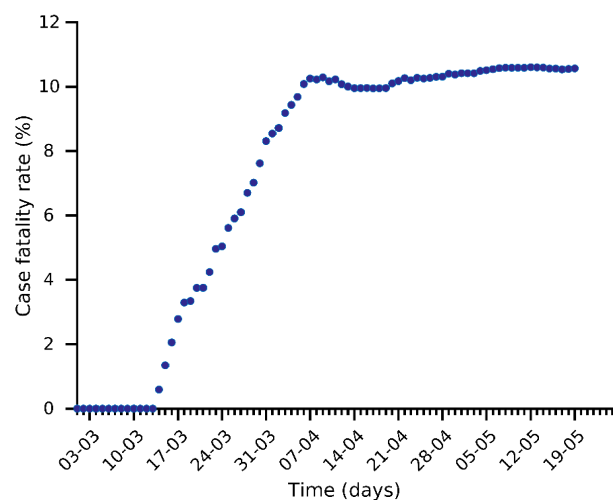
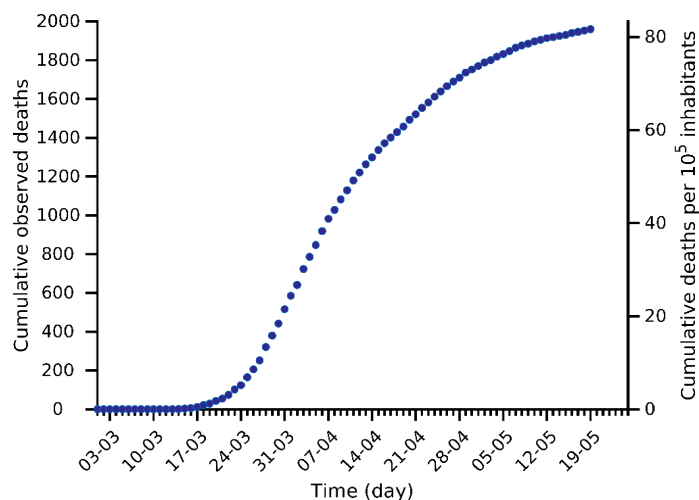
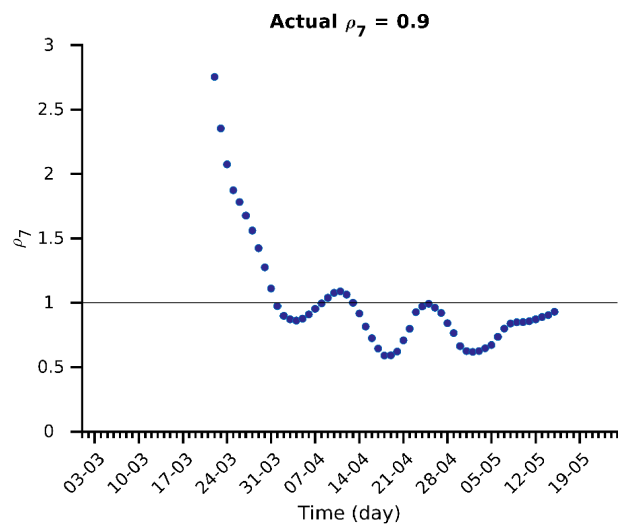
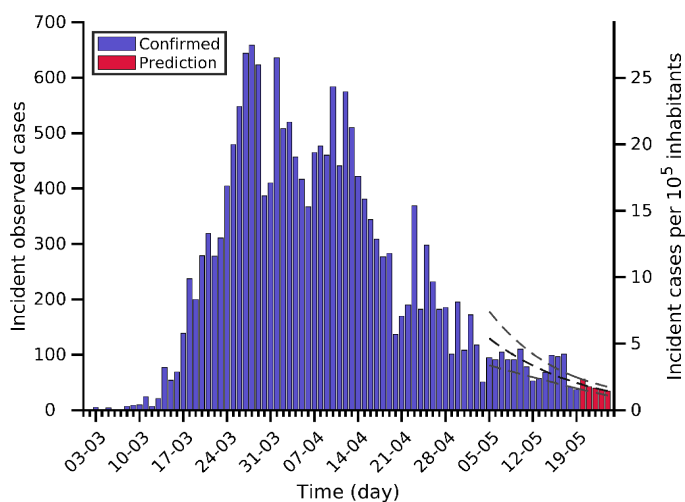
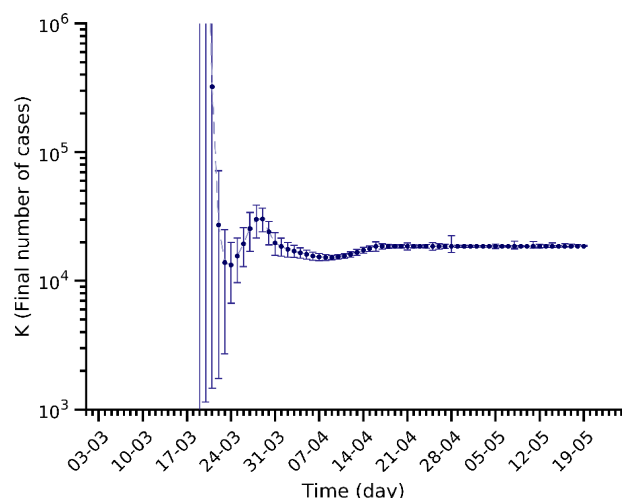
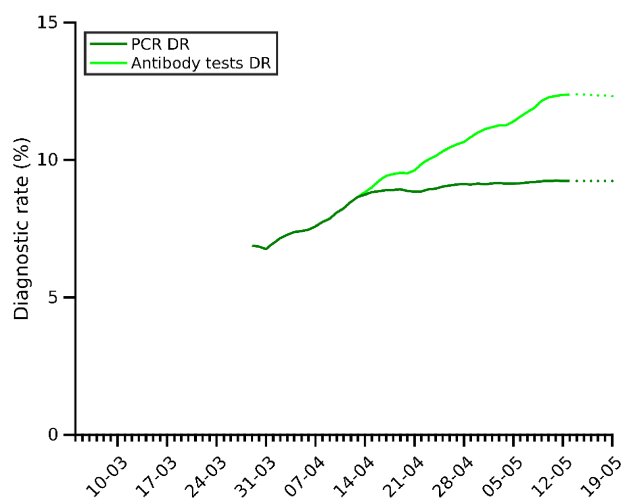
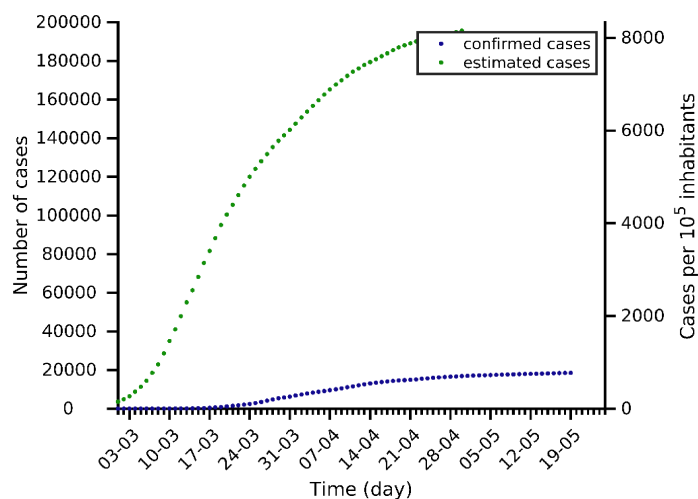
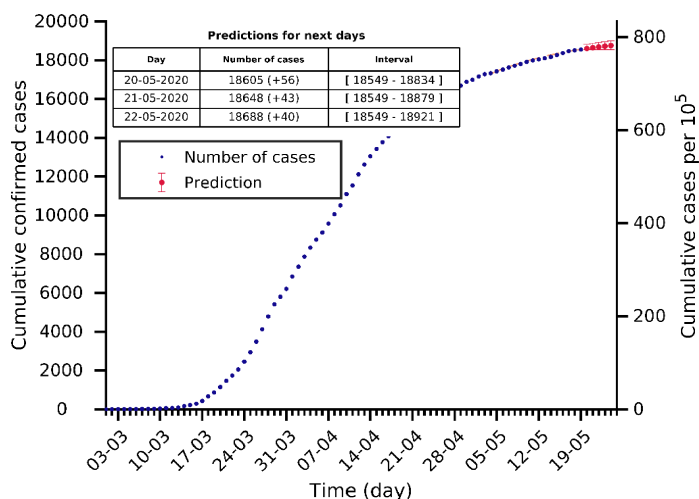
Madrid 19-05-2020. Population: 6.7M. Current cumulated incidence: 1000/10⁵



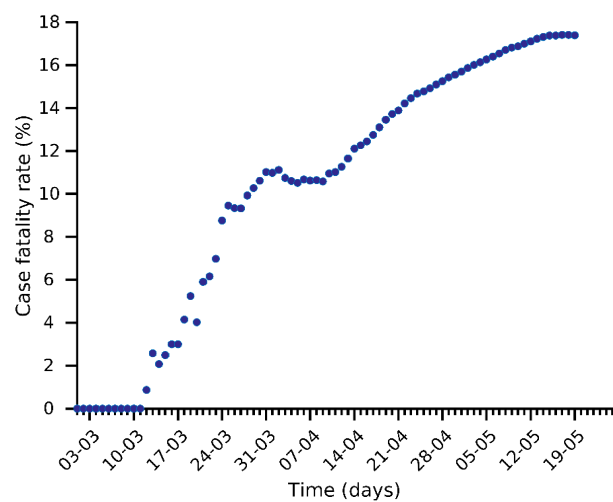
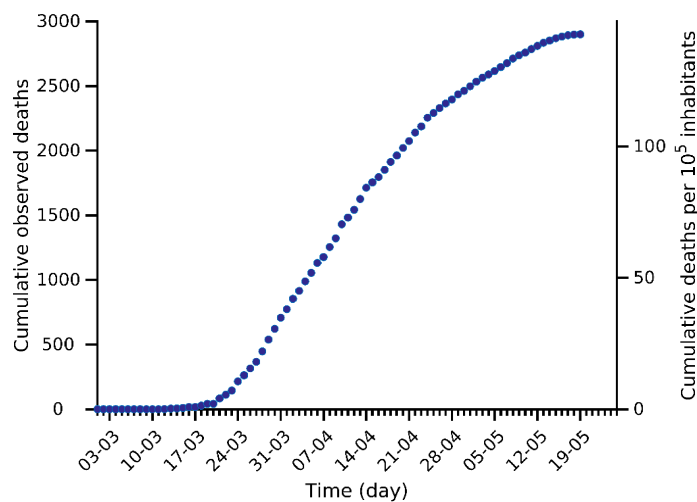
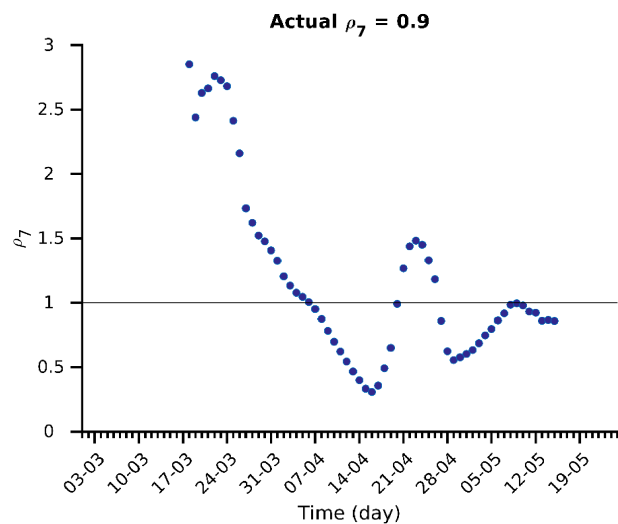
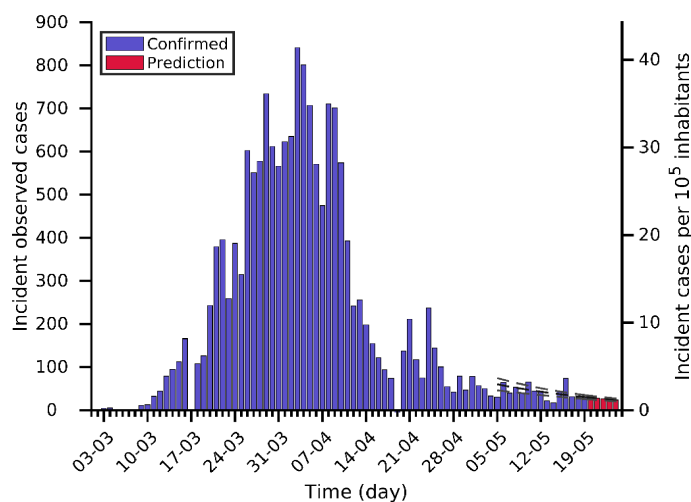
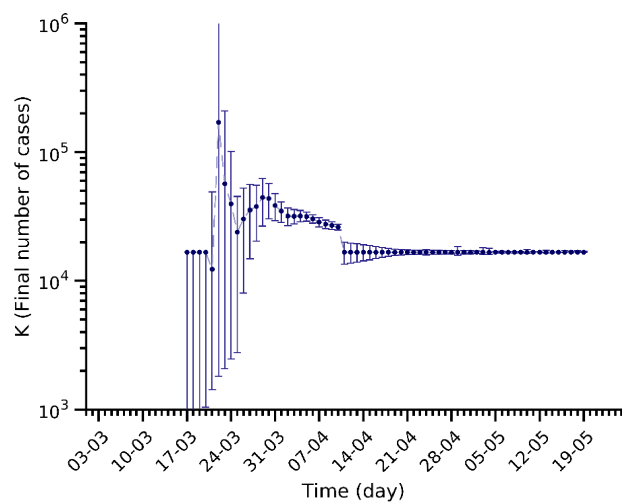
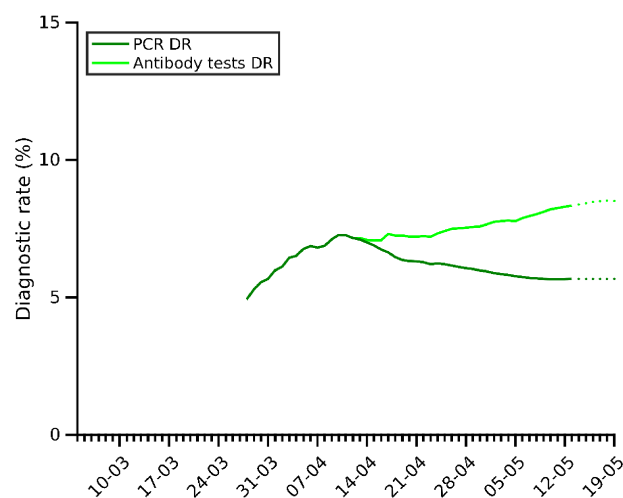
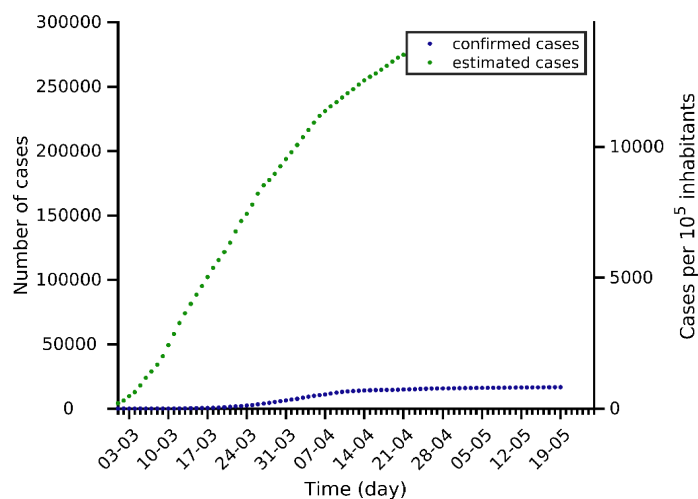
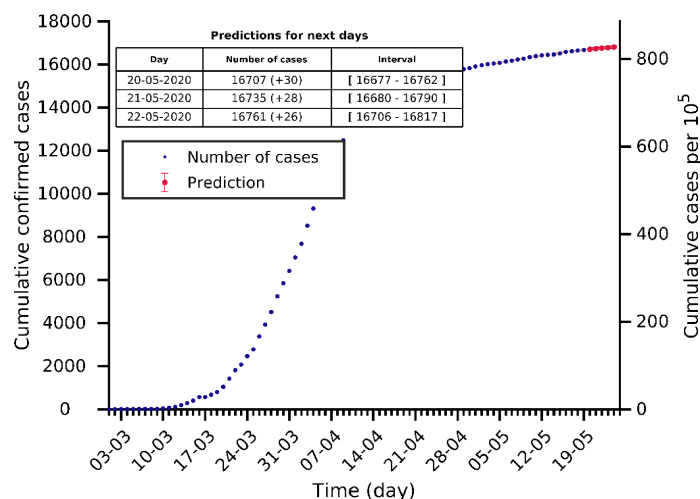
Catalunya 19-05-2020. Population: 7.7M. Current cumulated incidence: 695/10⁵



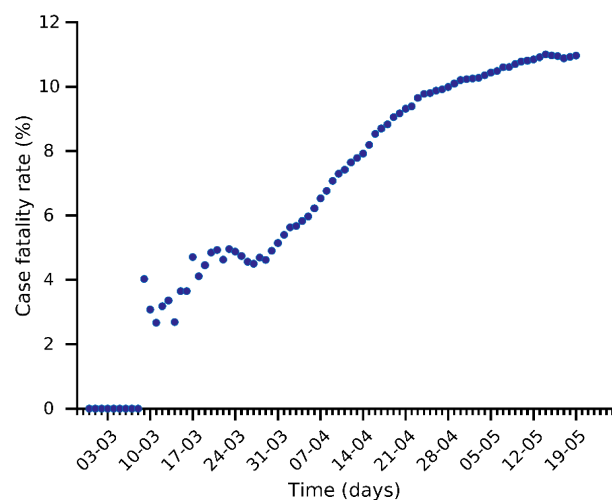
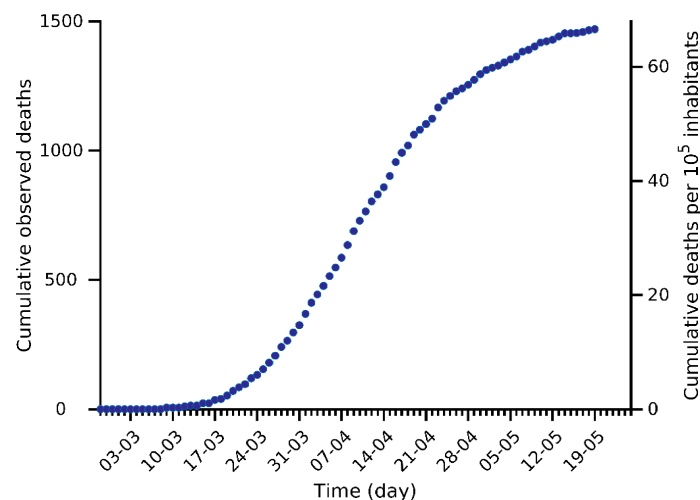
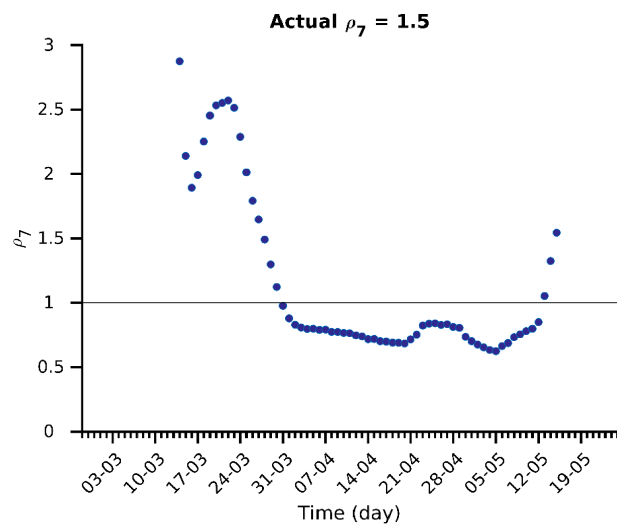
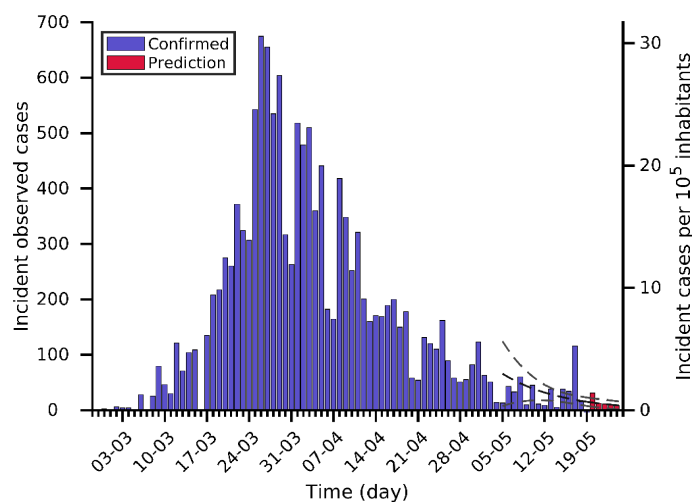
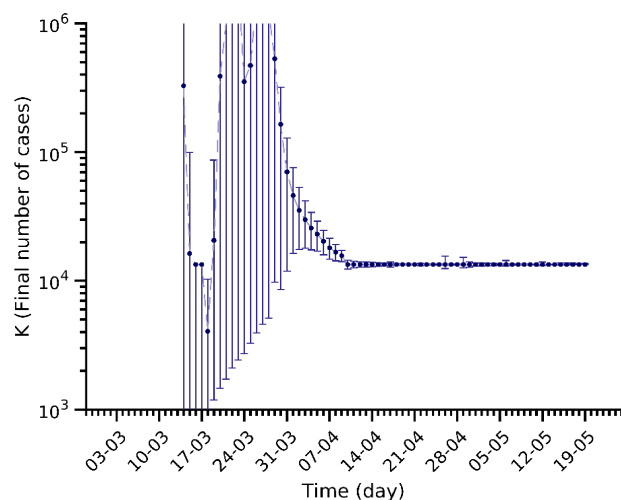
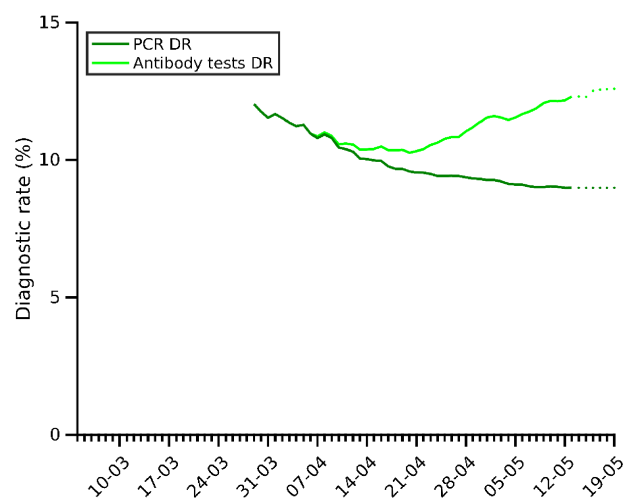
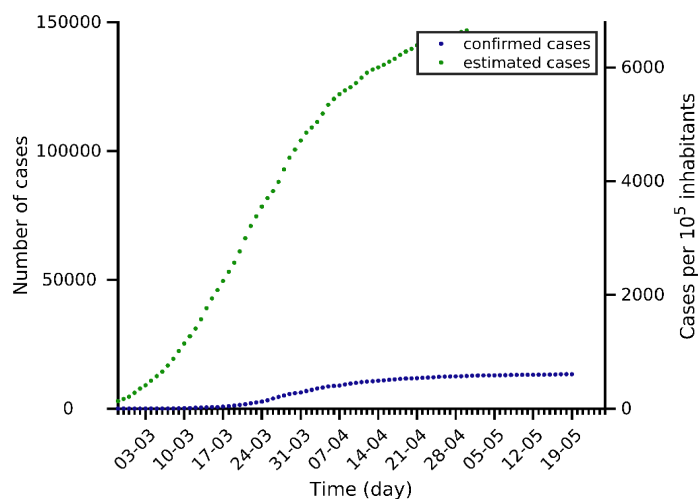
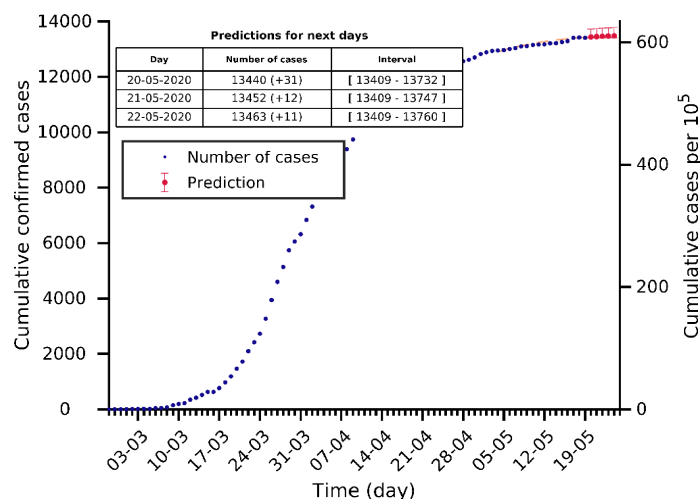
Castilla Leon 19-05-2020. Population: 2.4M. Current cumulated incidence: 773/10⁵



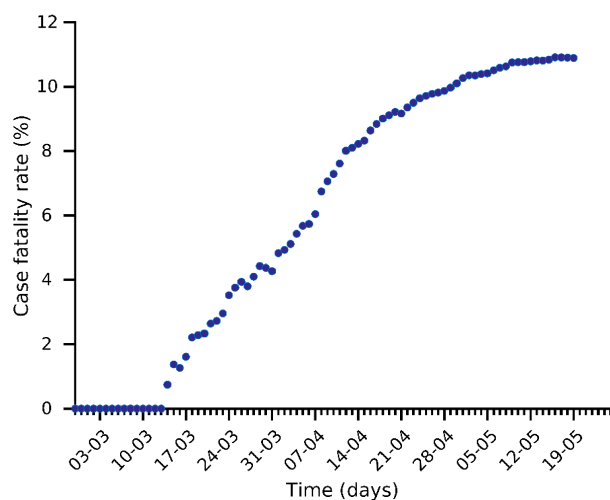
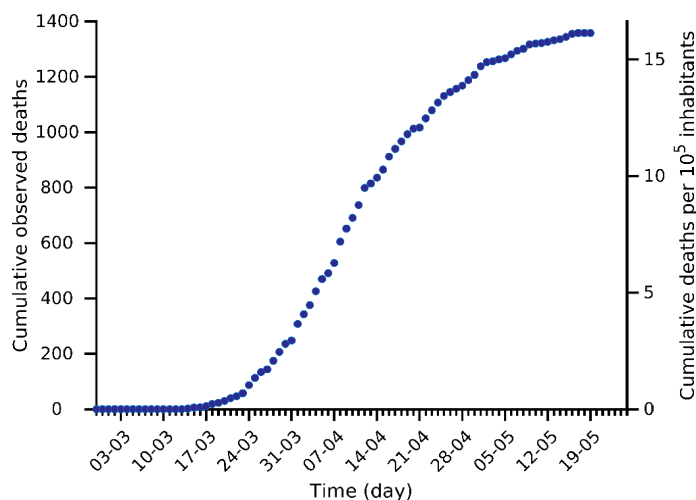
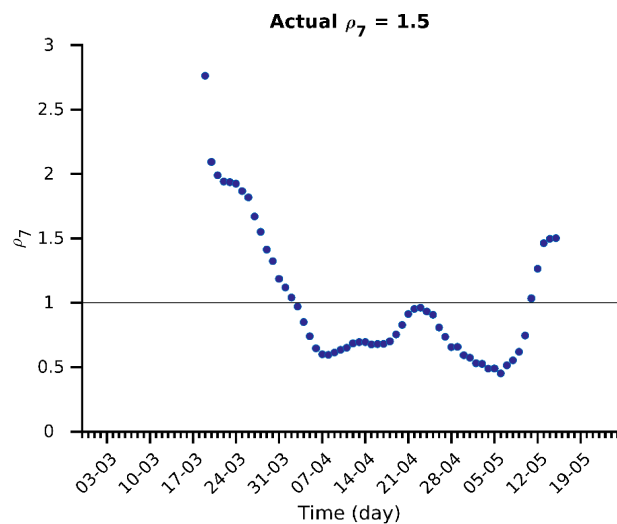
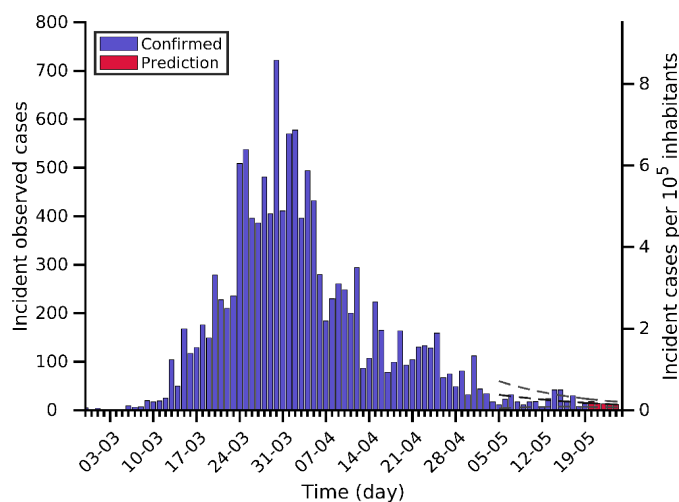
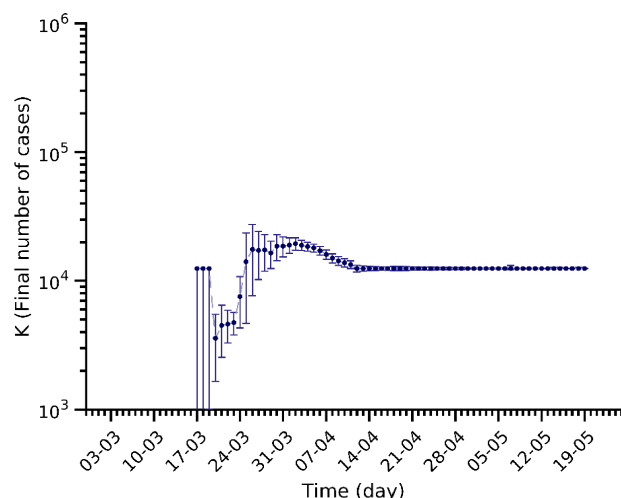
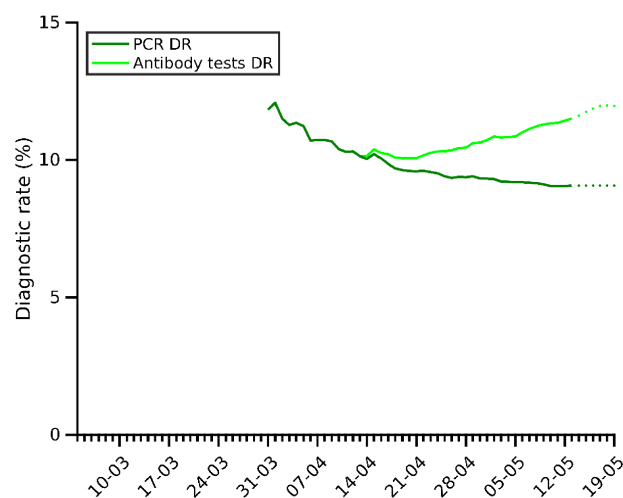
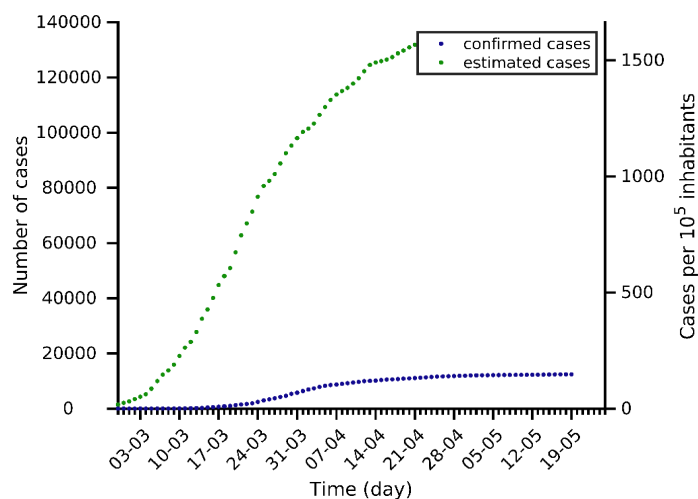
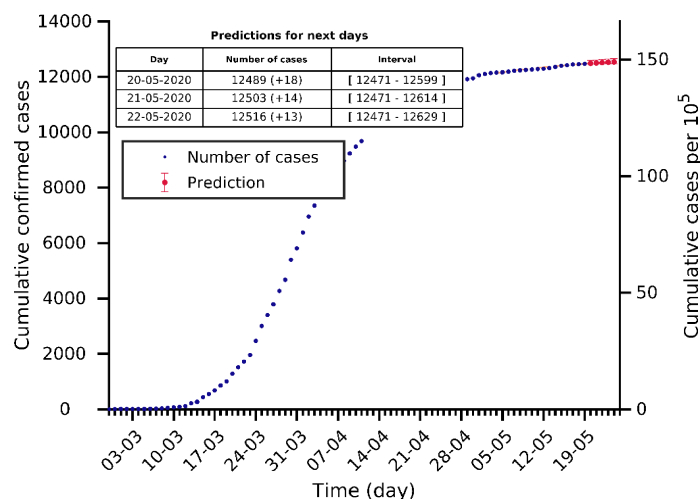
Castilla-La Mancha 19-05-2020. Population: 2.0M. Current cumulated incidence: 82



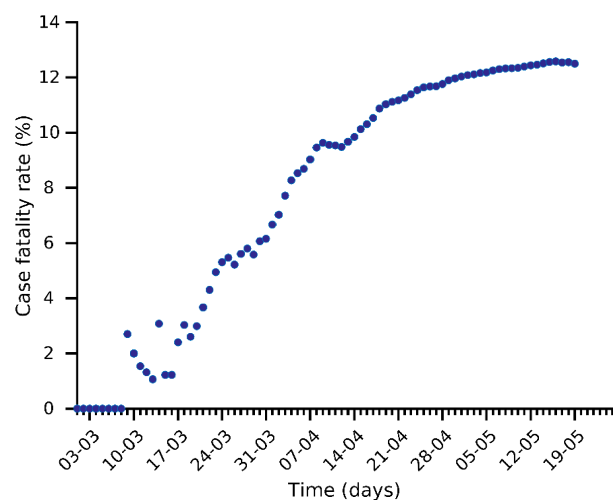
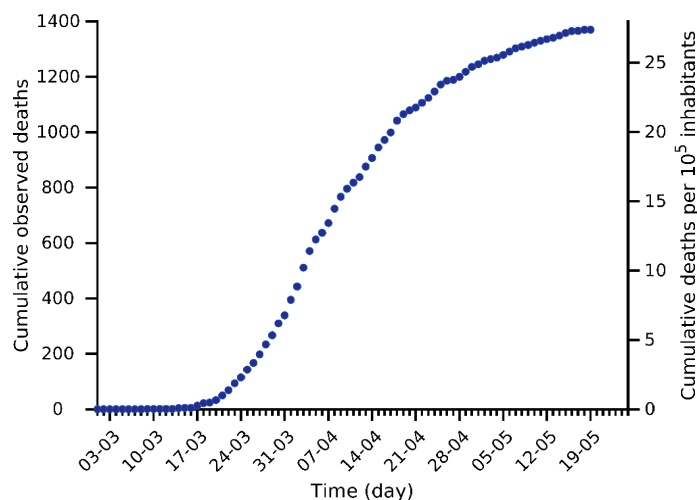
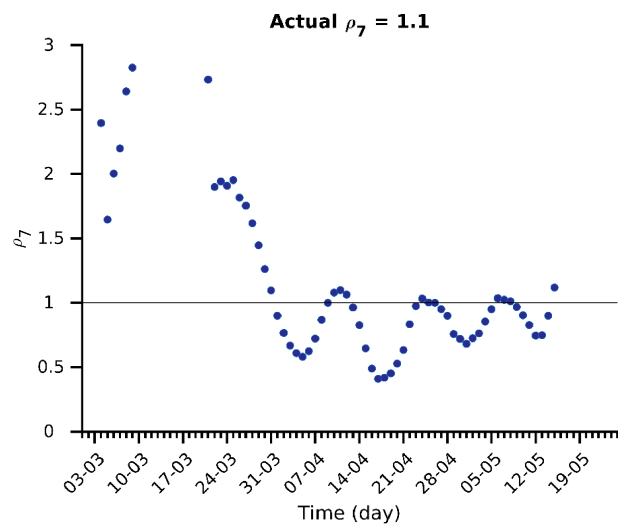
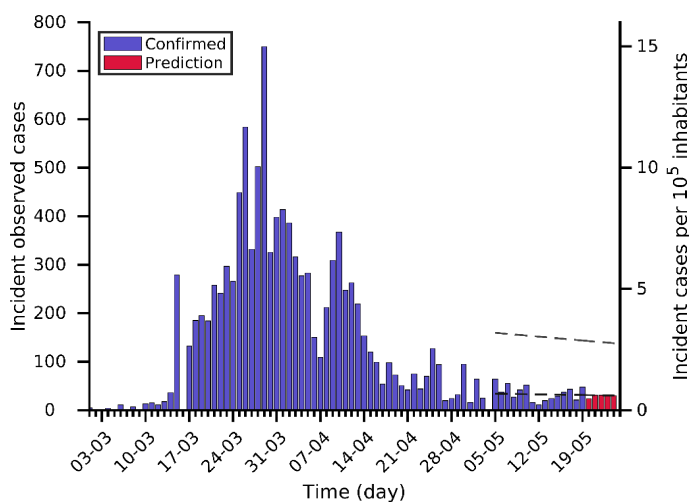
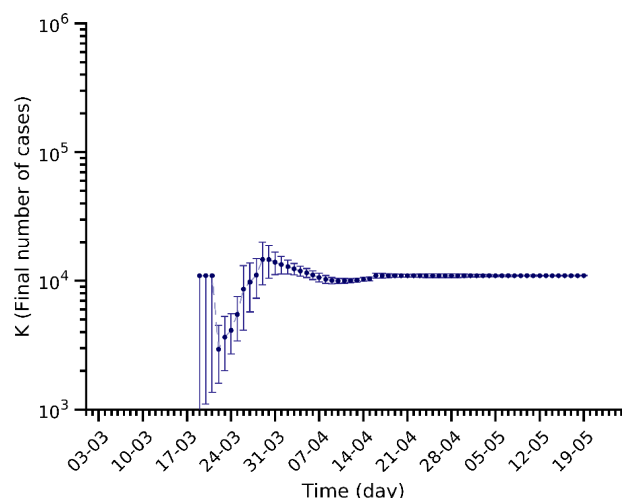
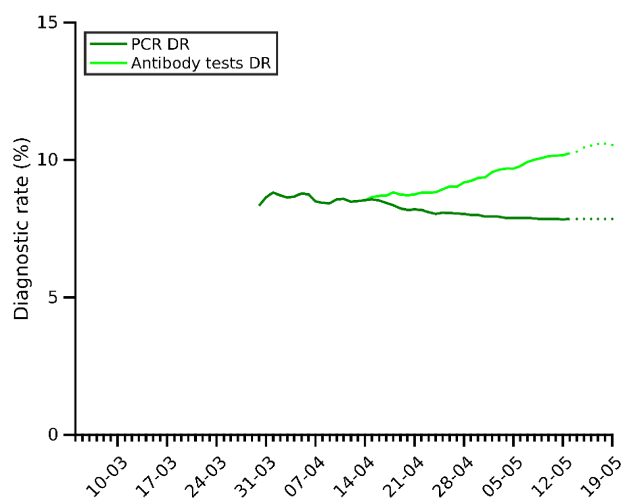
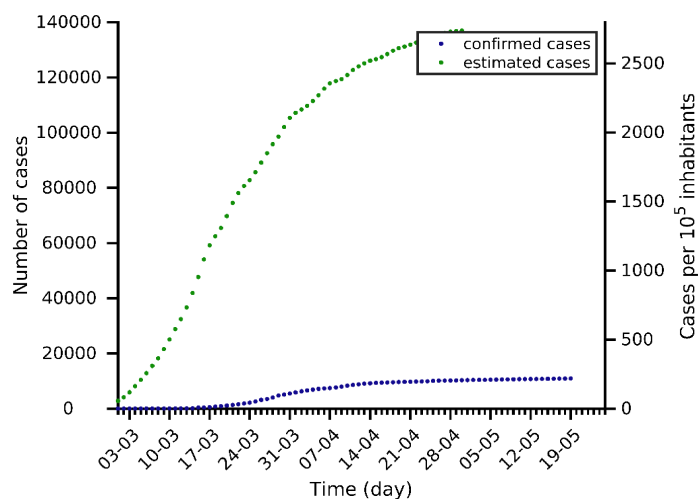
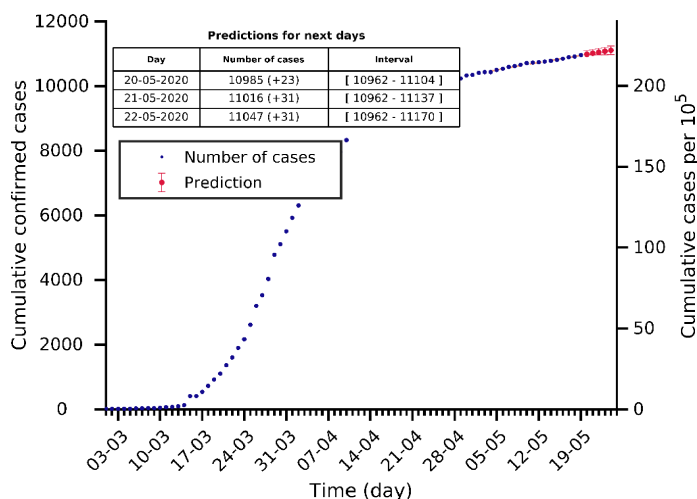
Euskadi 19-05-2020. Population: 2.2M. Current cumulated incidence: 607/10⁵



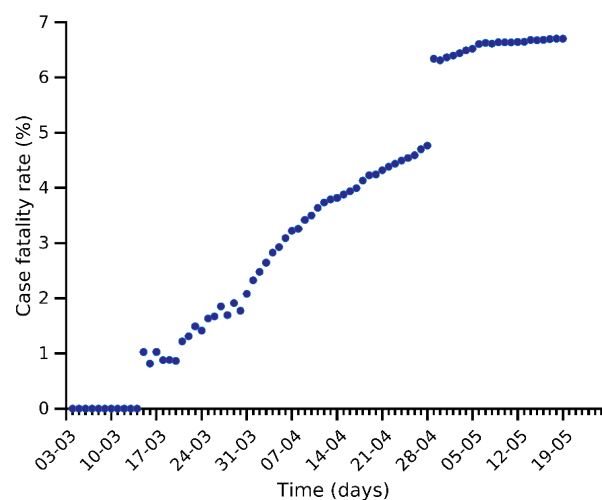
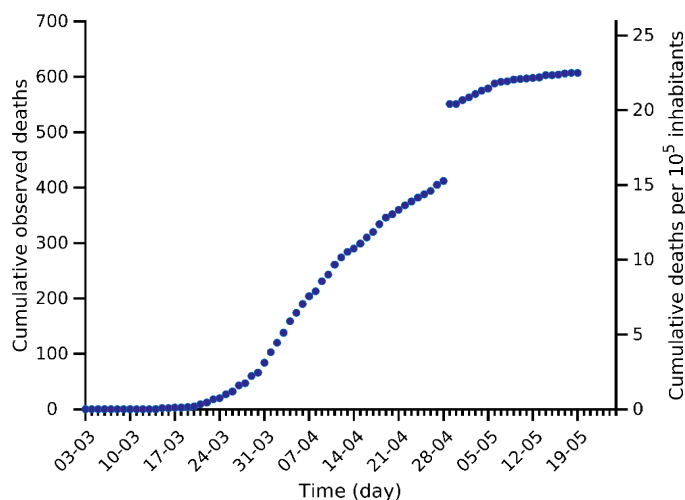
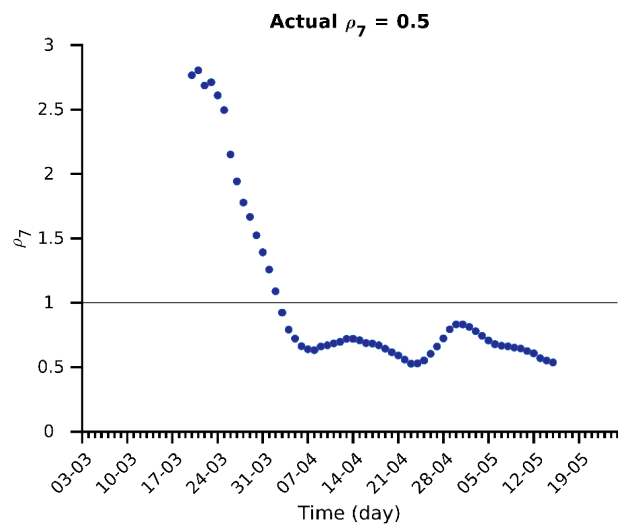
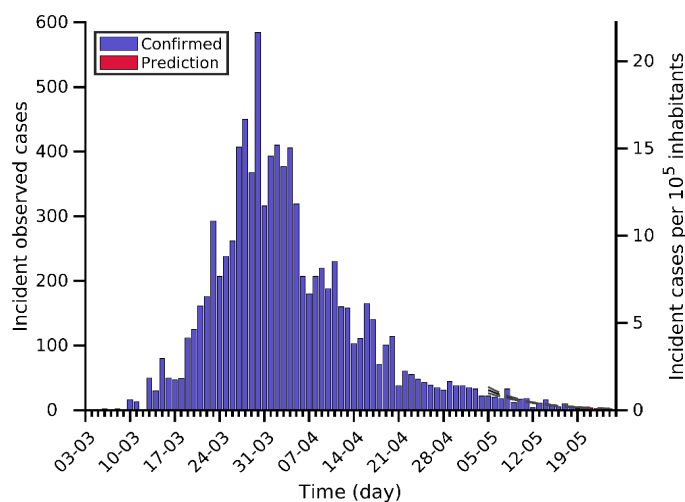
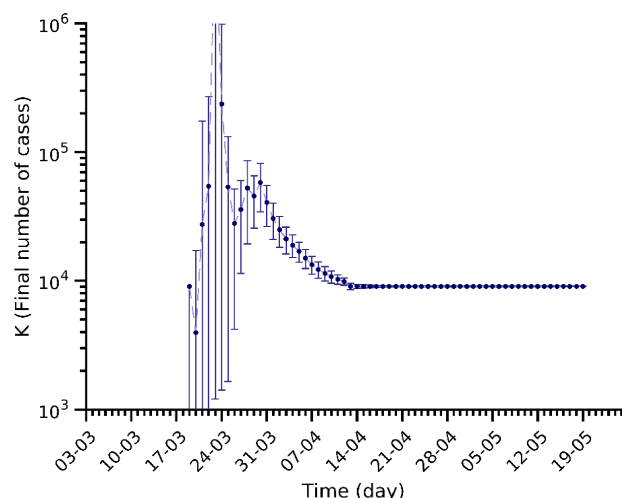
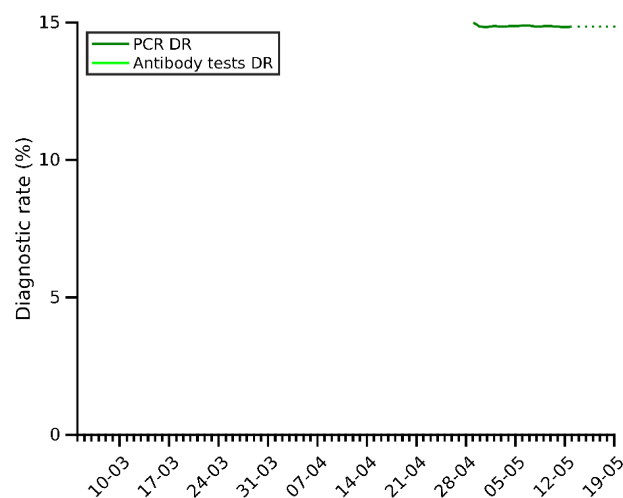
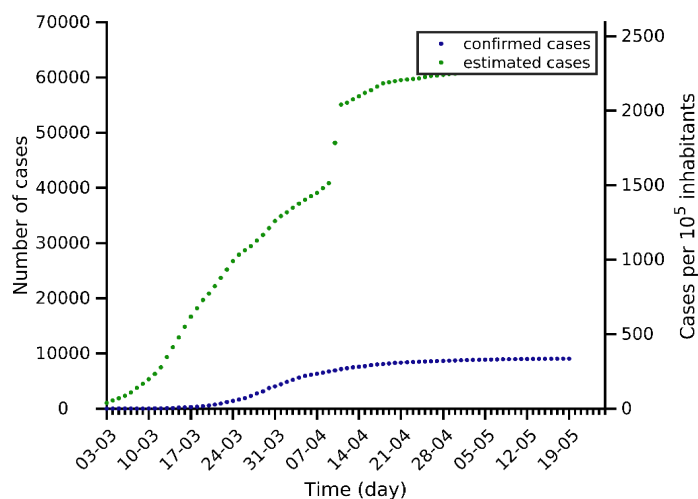
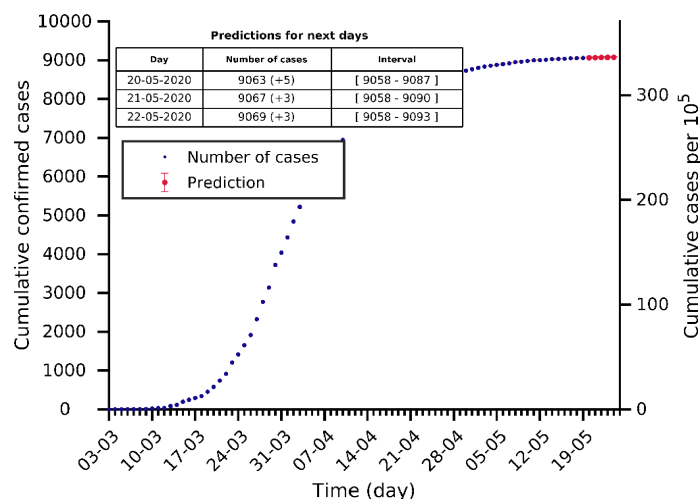
Andalucia 19-05-2020. Population: 8.4M. Current cumulated incidence: 148/10⁵



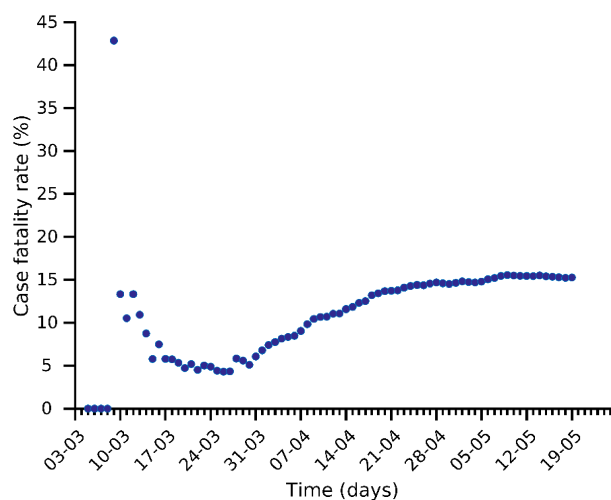
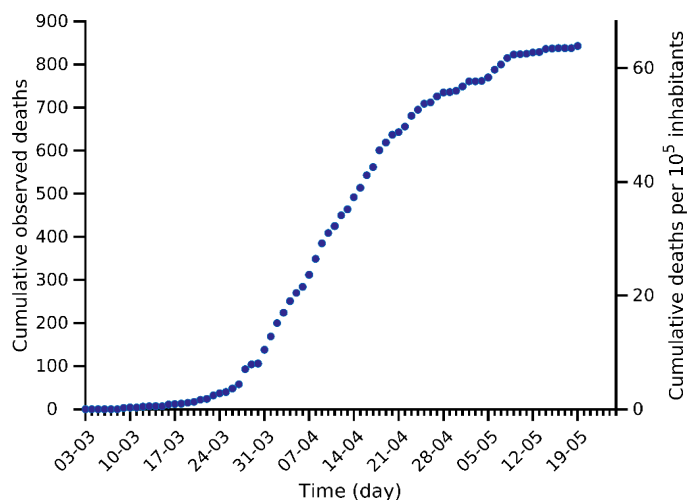
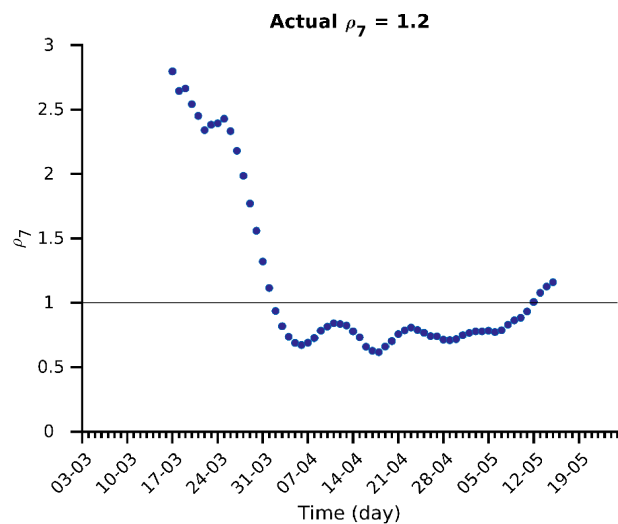
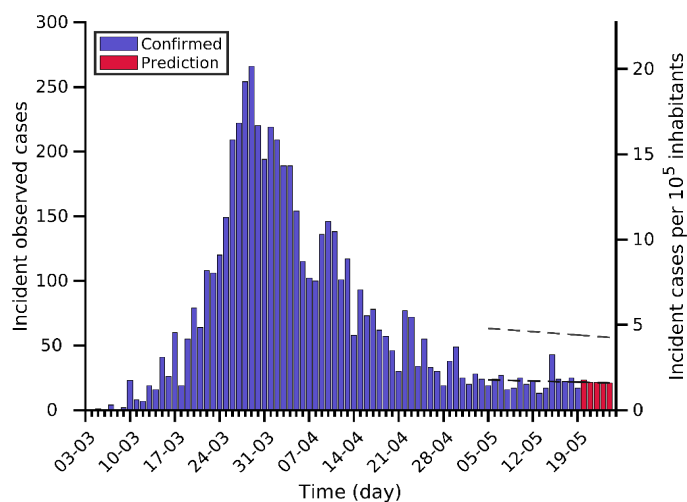
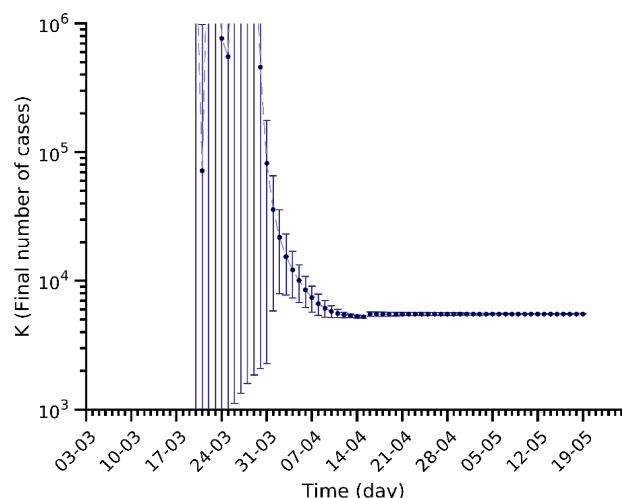
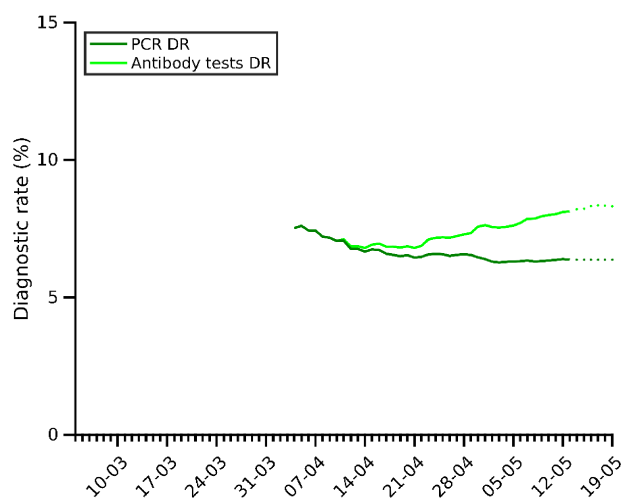
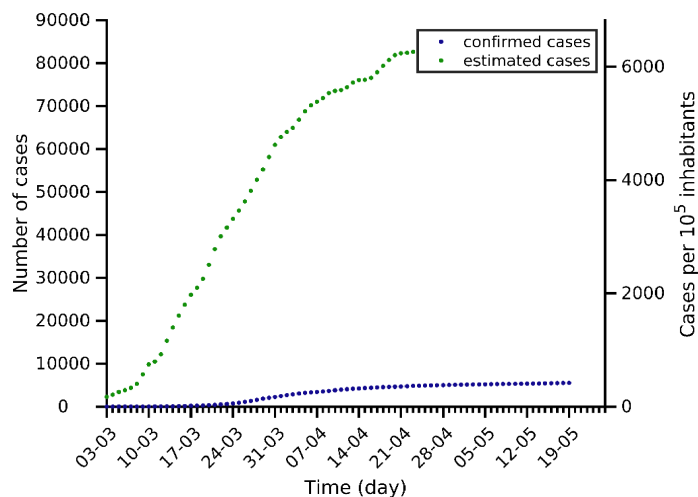
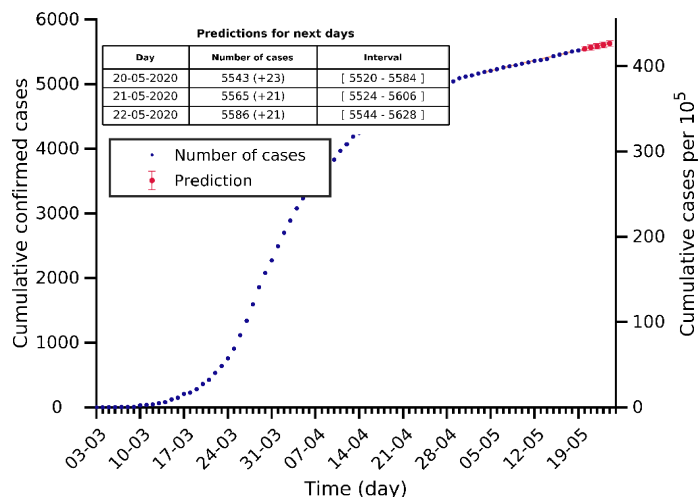
C Valenciana 19-05-2020. Population: 5.0M. Current cumulated incidence: 219/10⁵



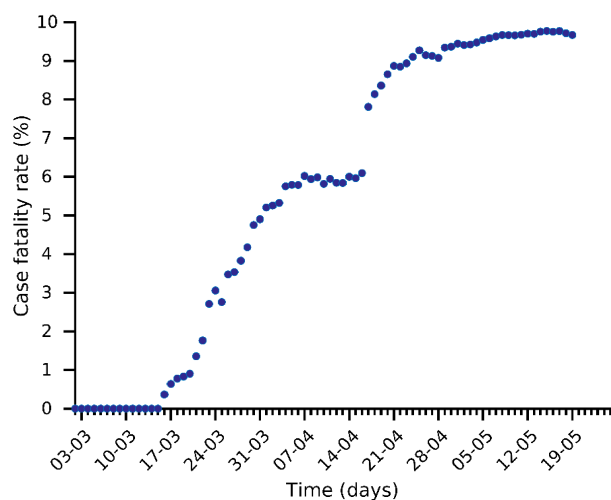
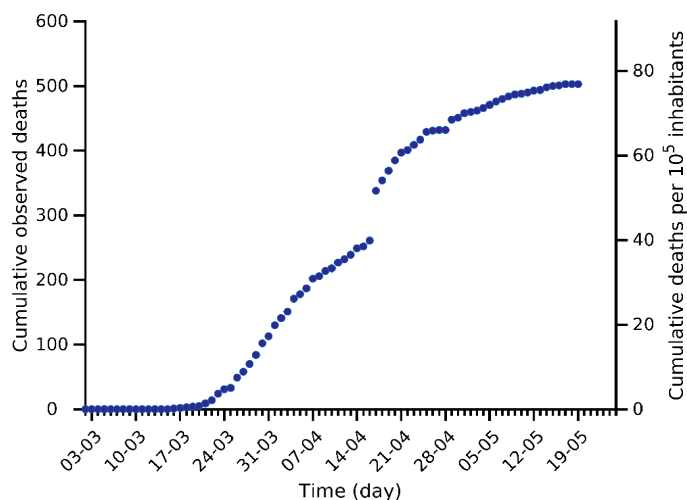
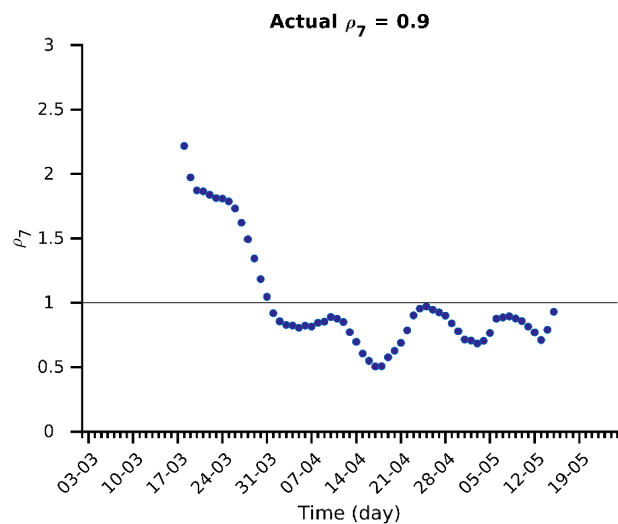
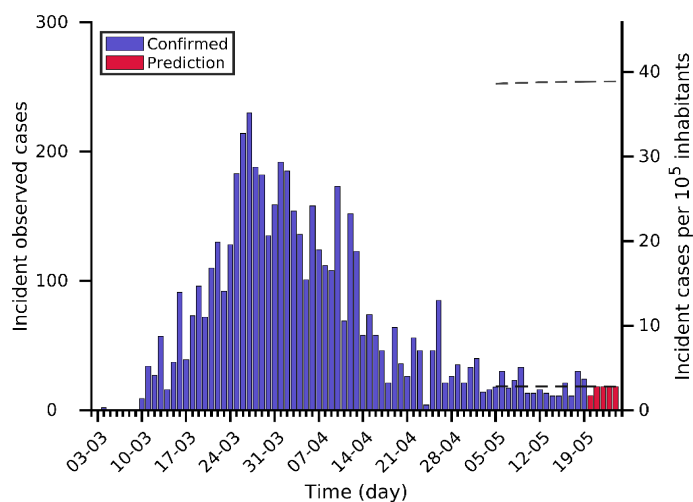
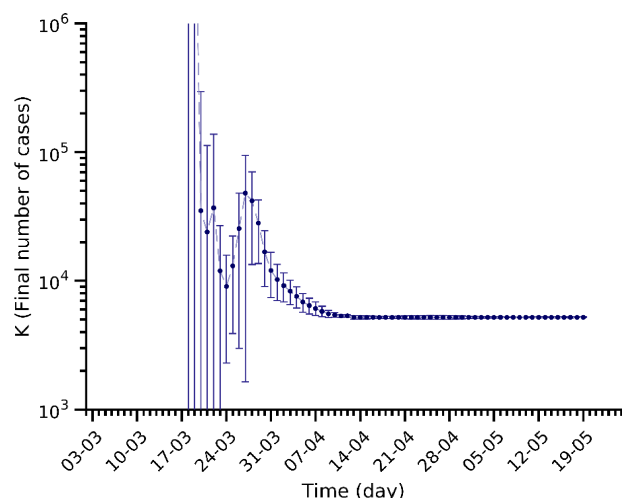
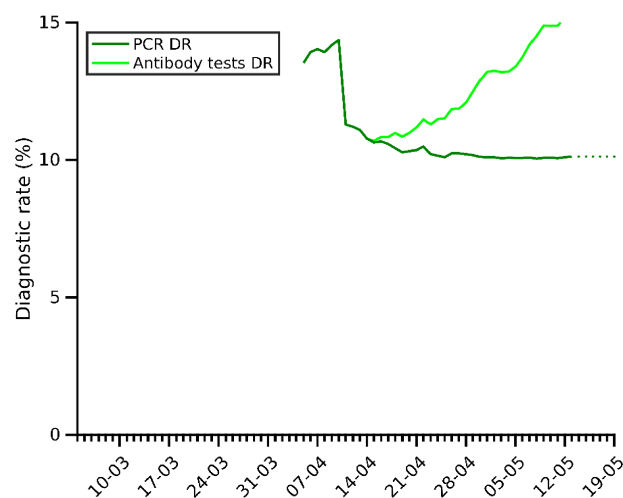
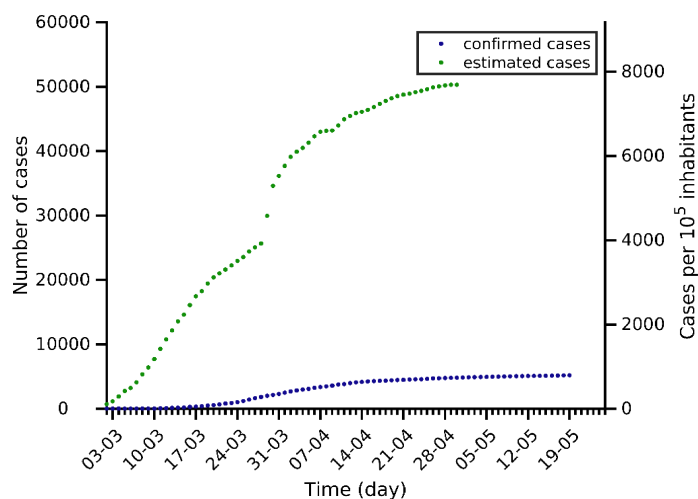
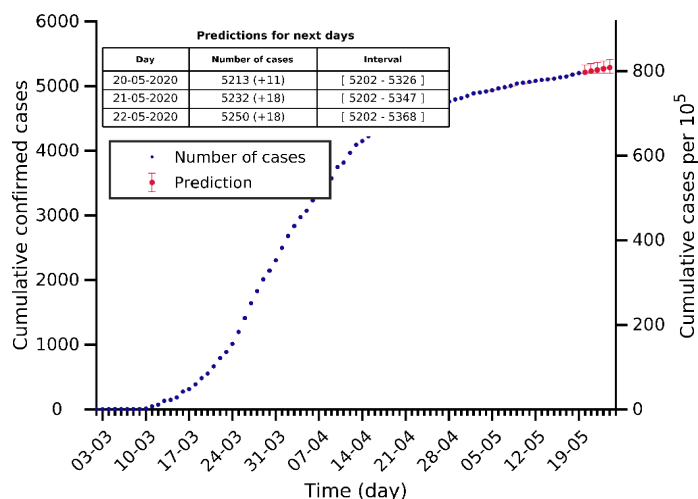
Galicia 19-05-2020. Population: 2.7M. Current cumulated incidence: 336/10⁵



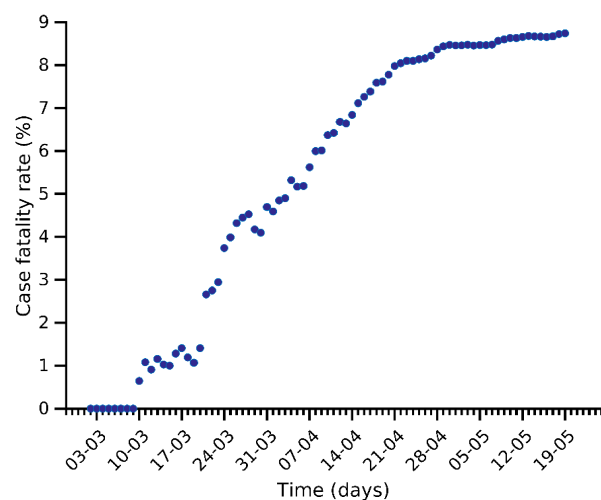
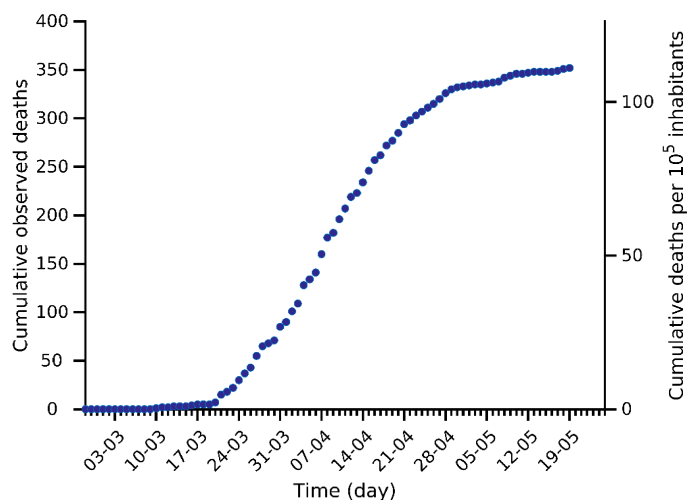
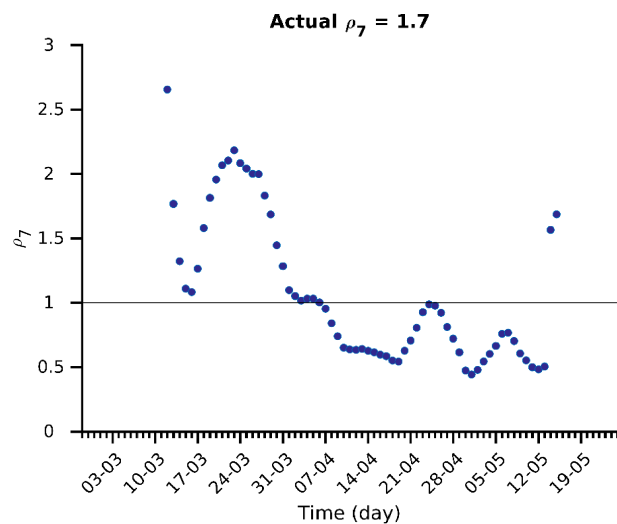
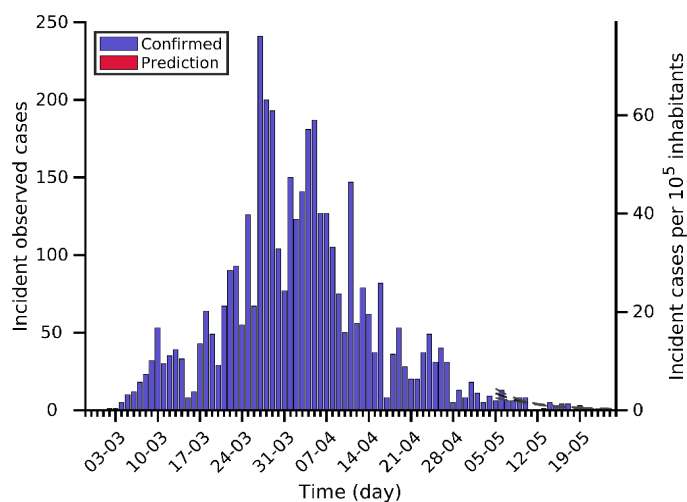
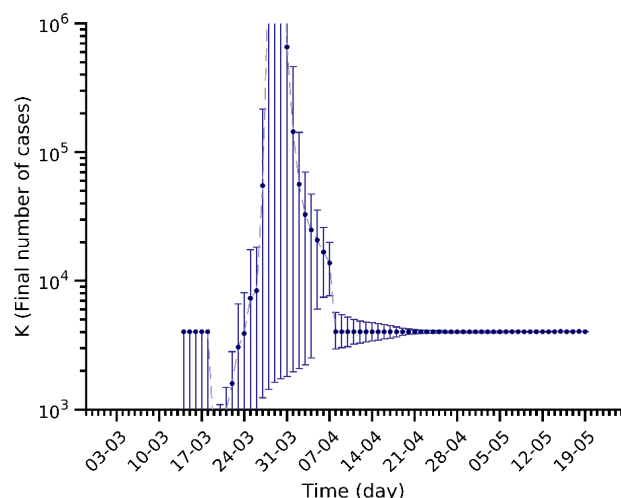
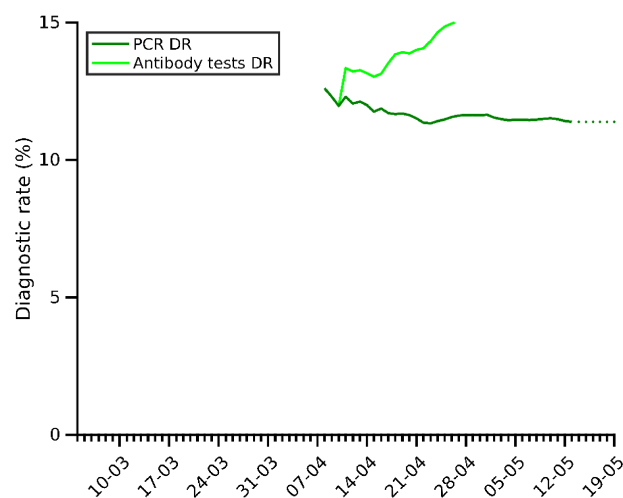
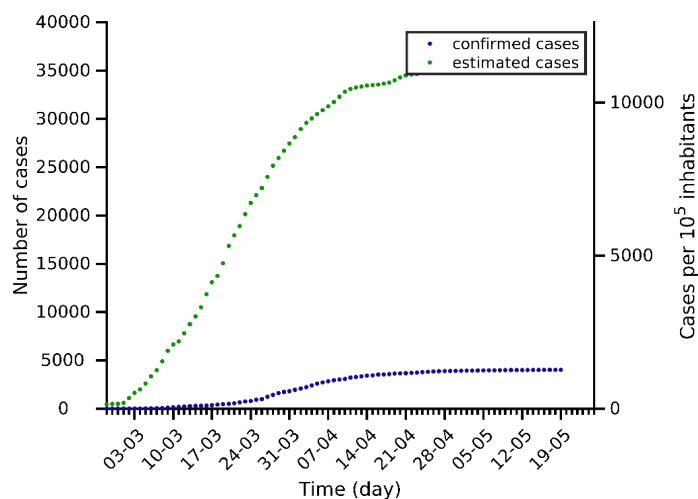
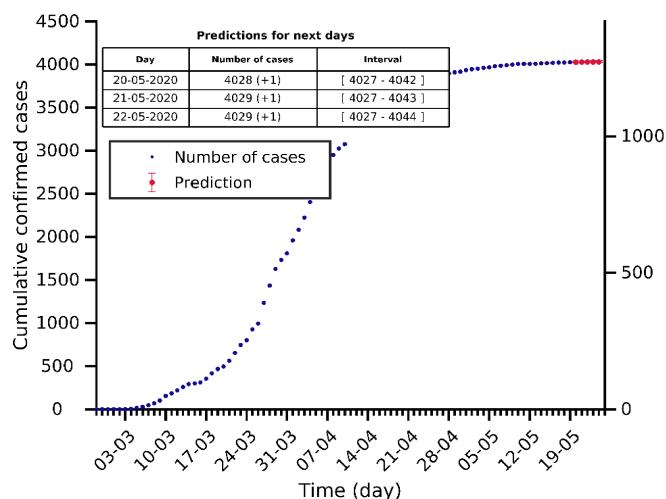
Aragon 19-05-2020. Population: 1.3M. Current cumulated incidence: 418/10⁵



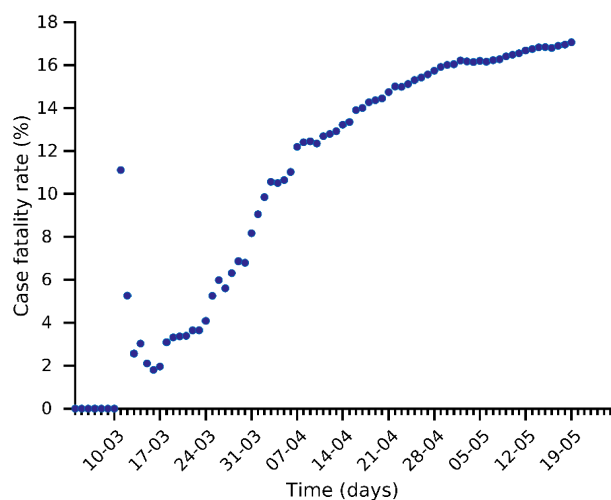
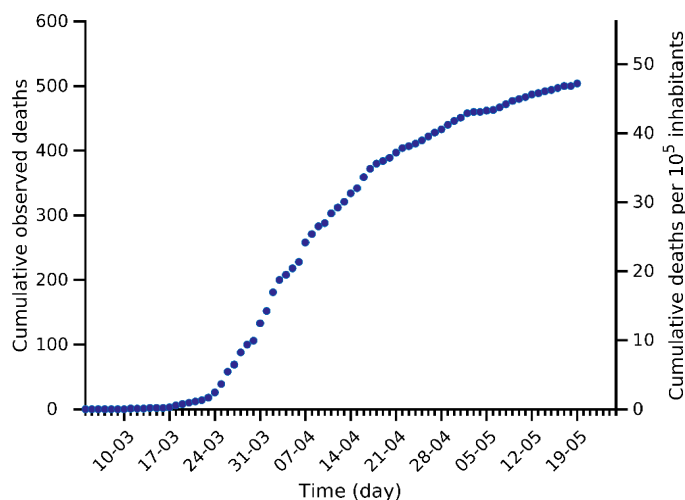
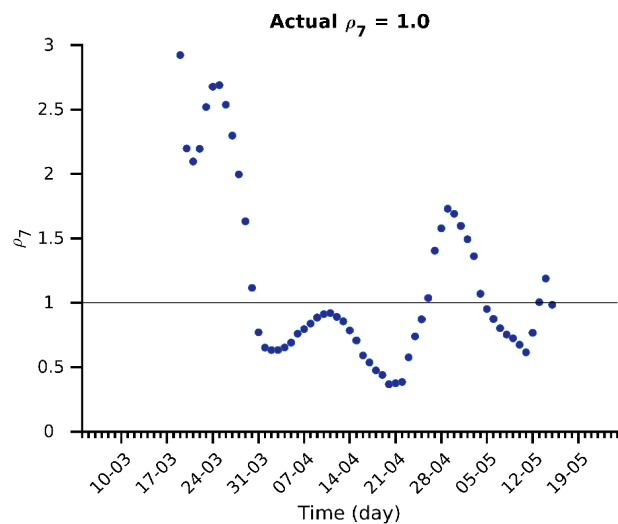
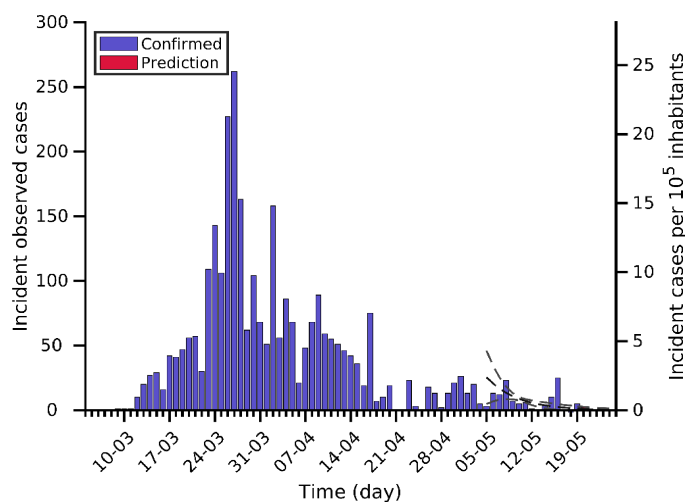
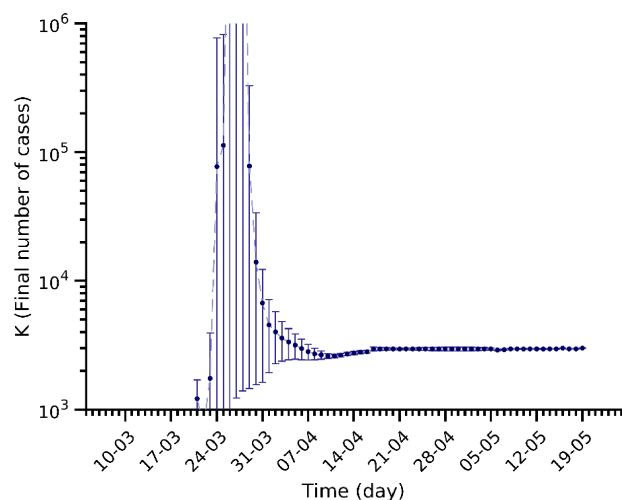
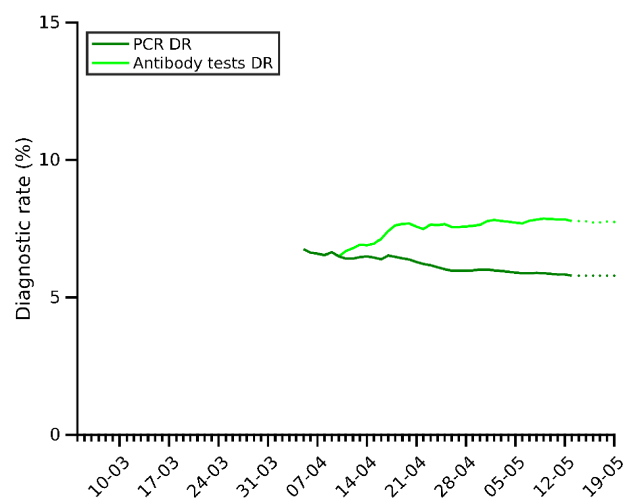
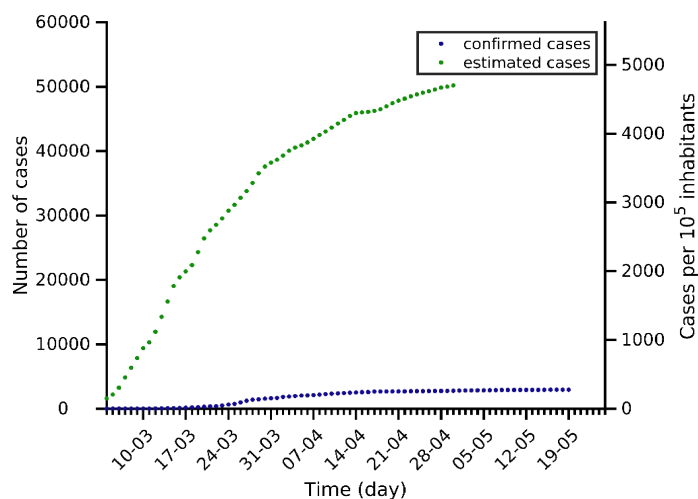
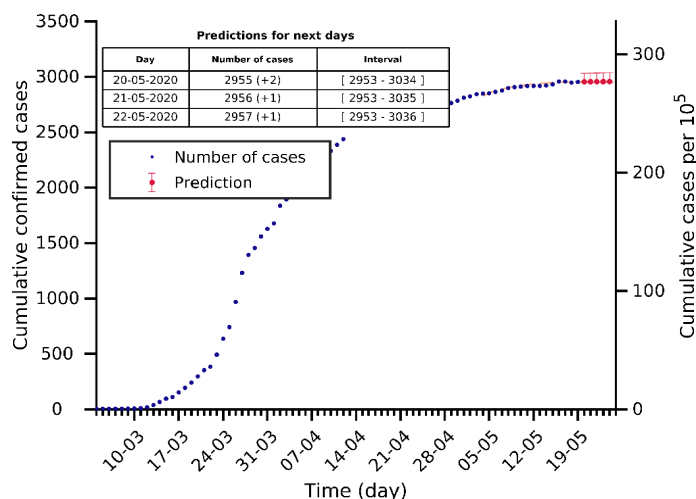
Navarra 19-05-2020. Population: 0.7M. Current cumulated incidence: 795/10⁵



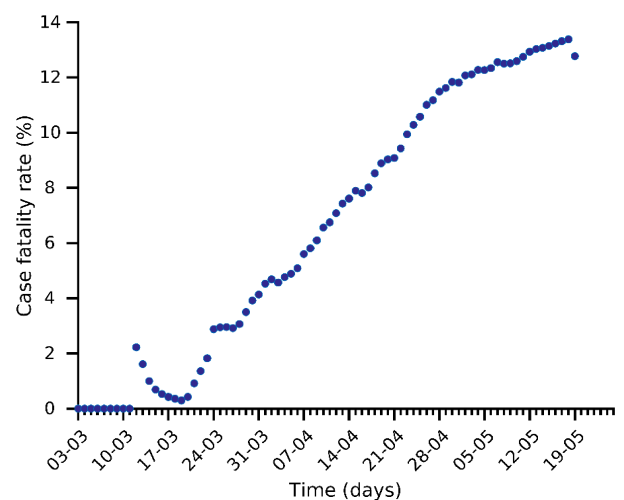
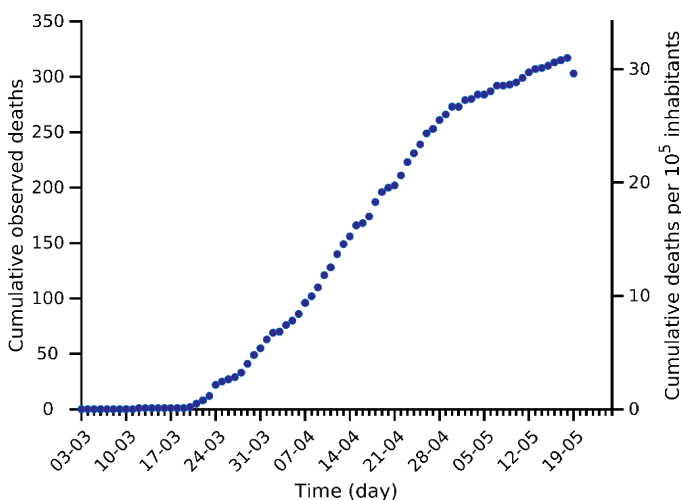
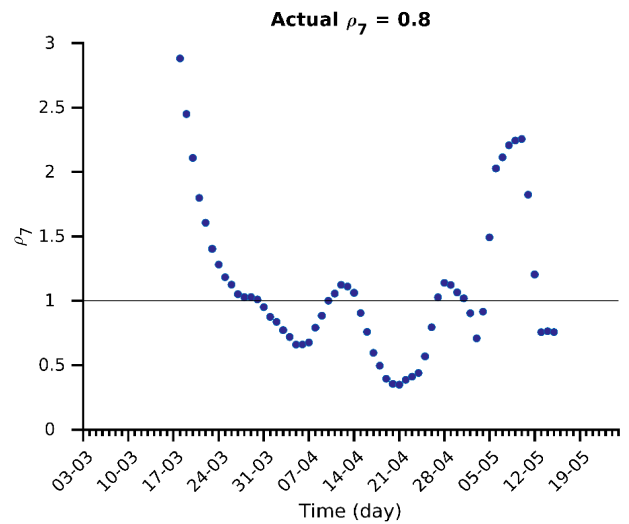
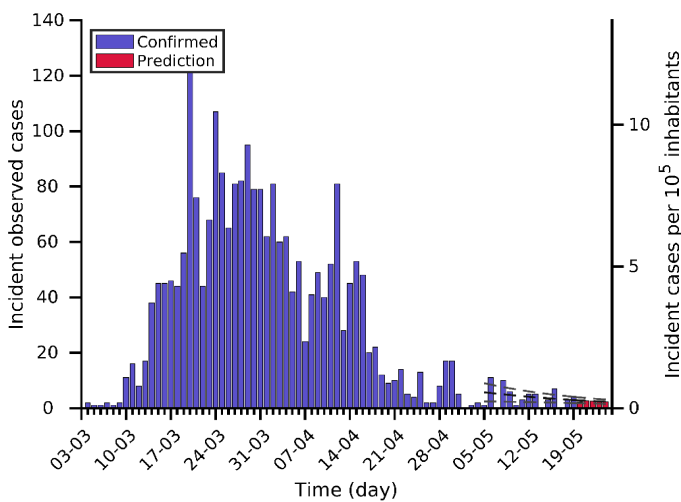
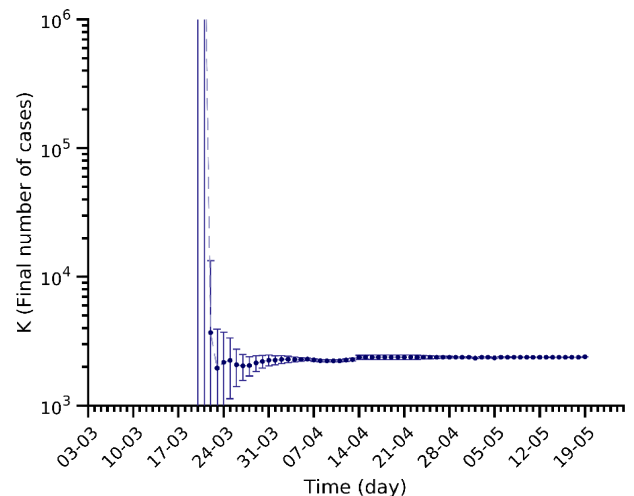
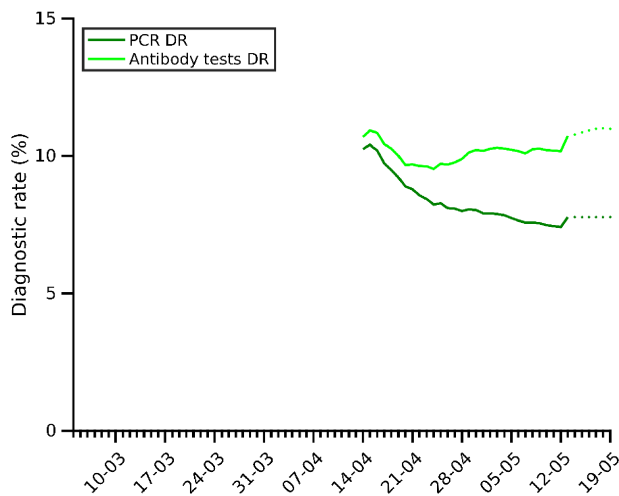
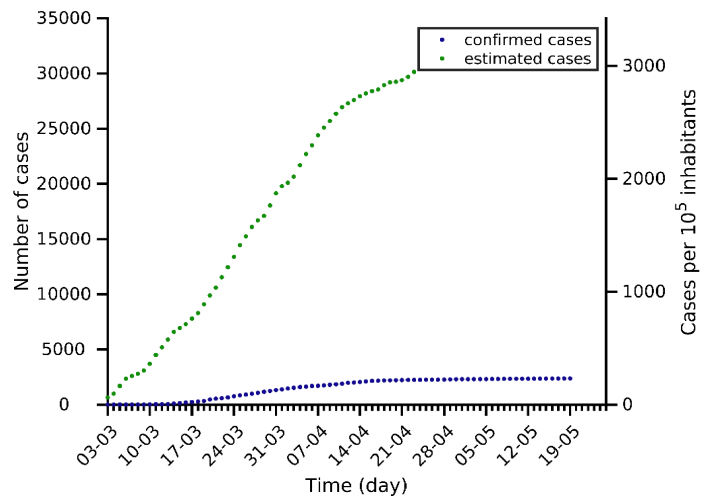
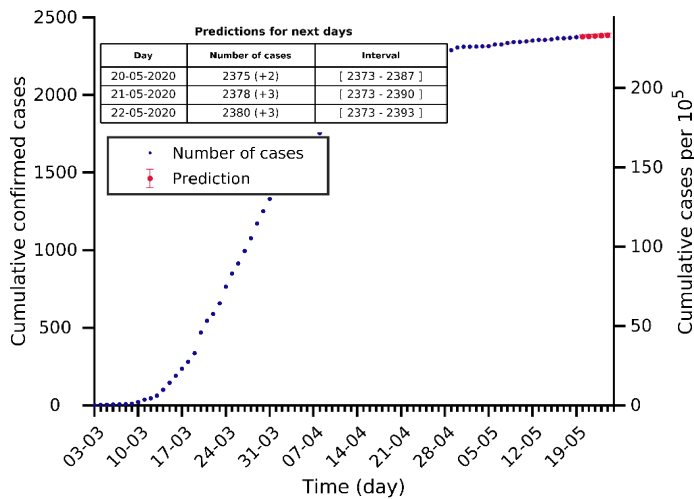
La Rioja 19-05-2020. Population: 0.3M. Current cumulated incidence: 1271/10⁵



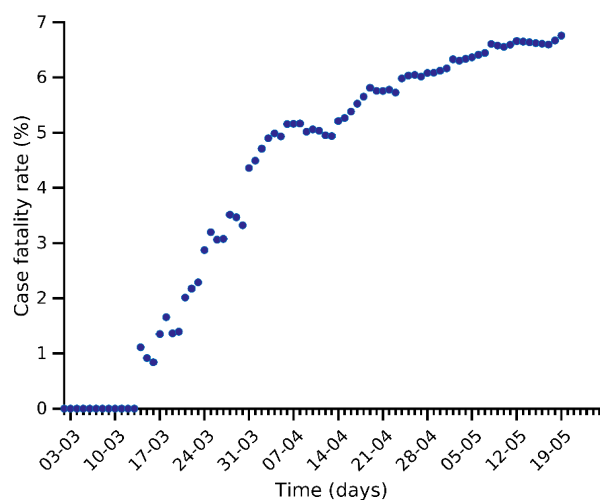
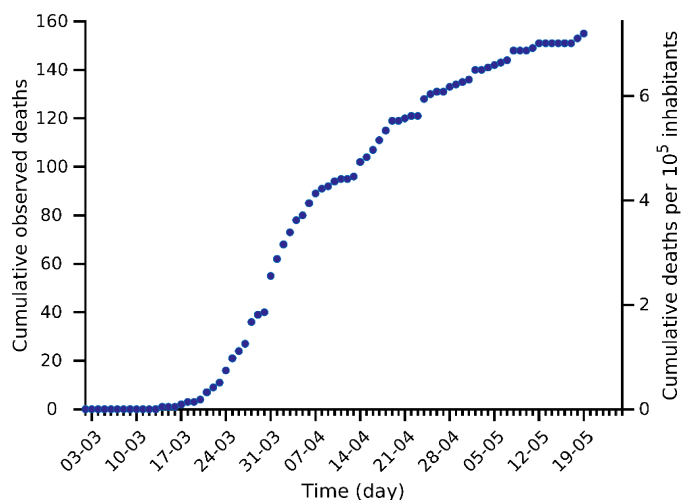
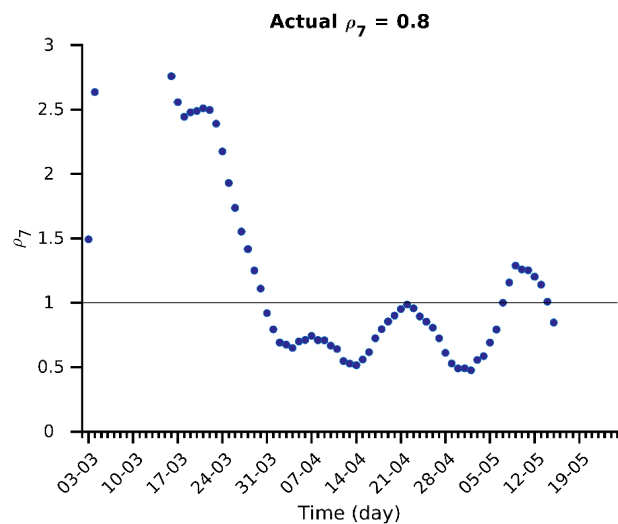
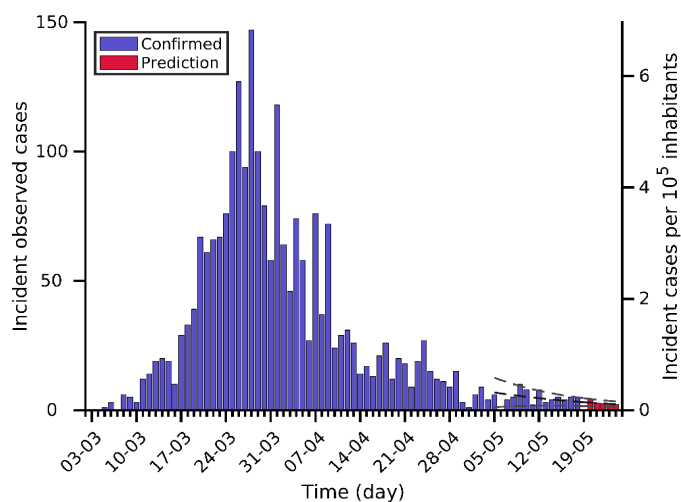
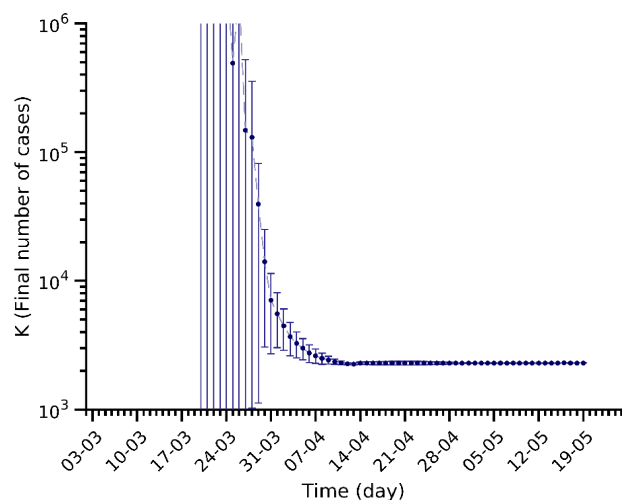
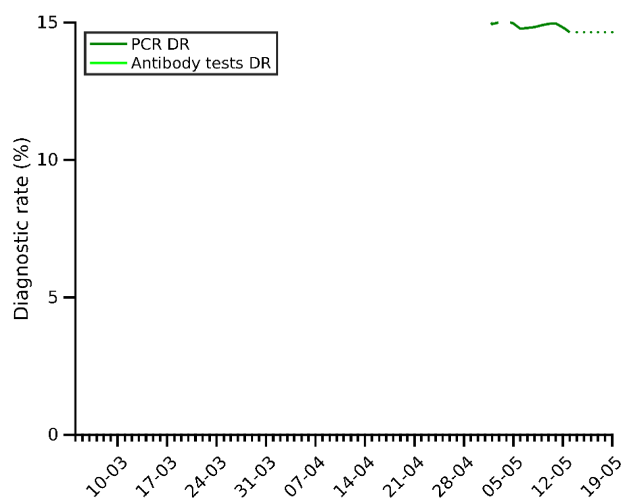
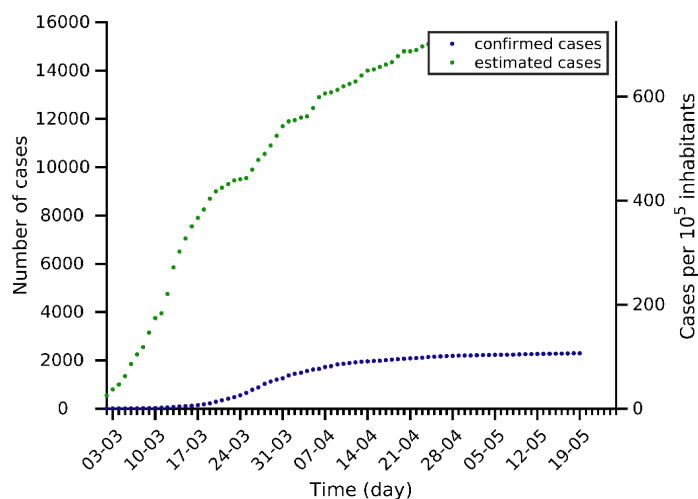
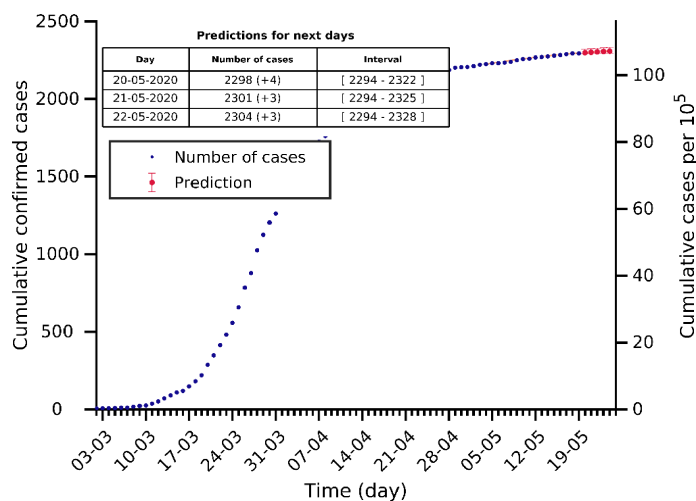
Extremadura 19-05-2020. Population: 1.1M. Current cumulated incidence: 277/10⁵



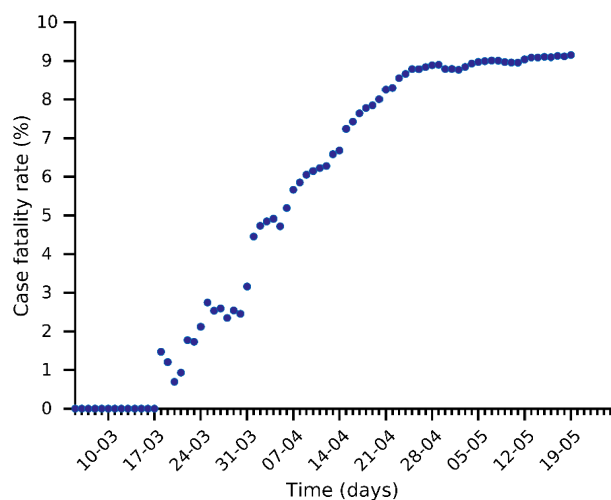
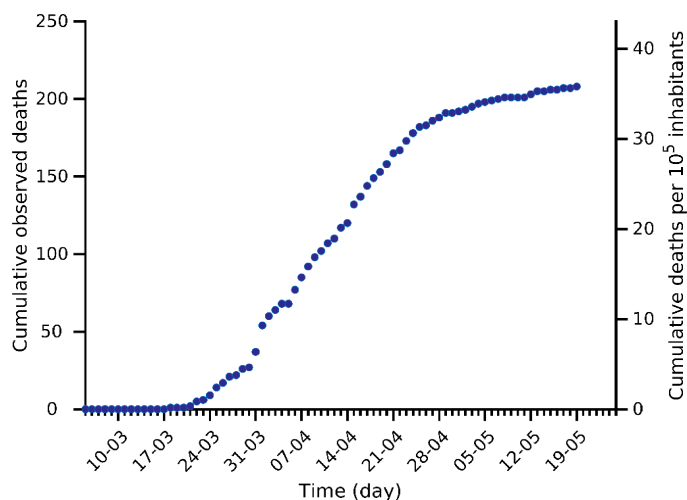
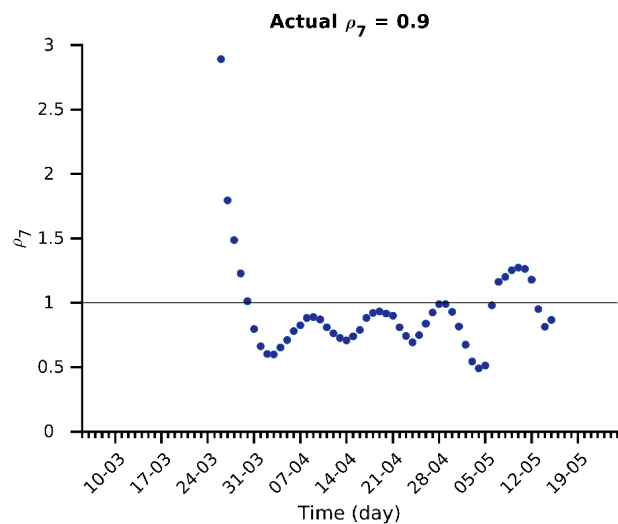
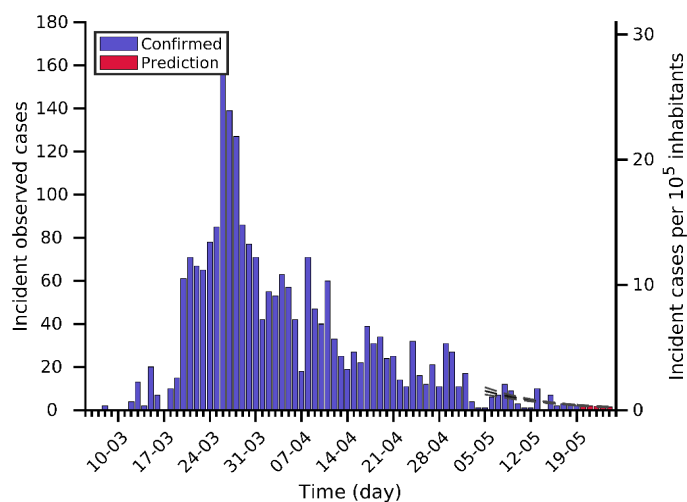
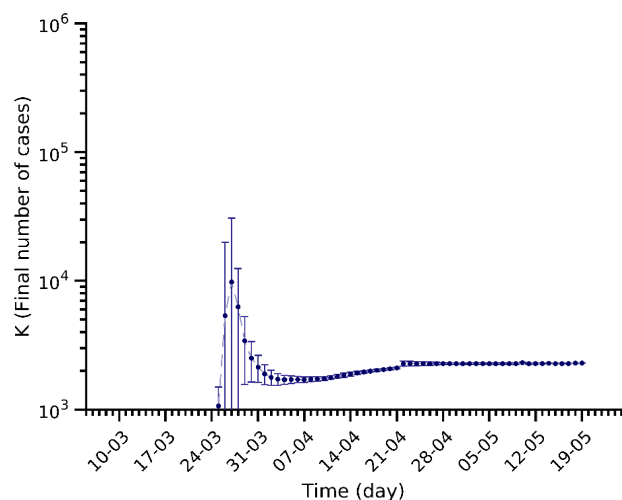
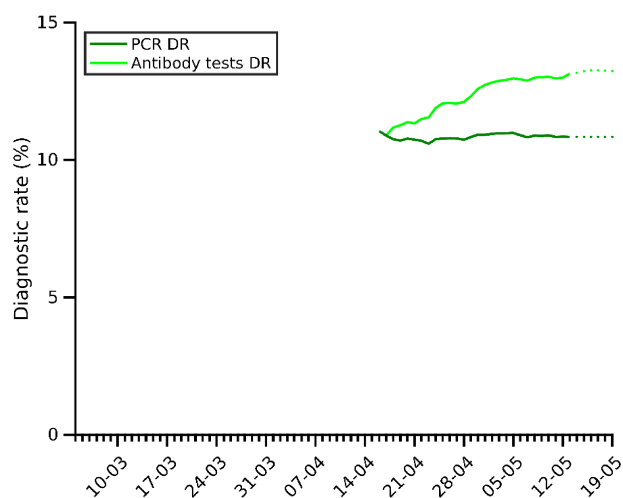
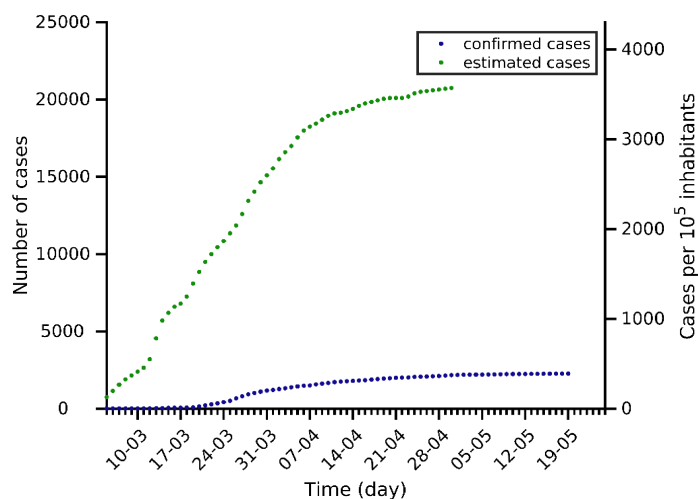
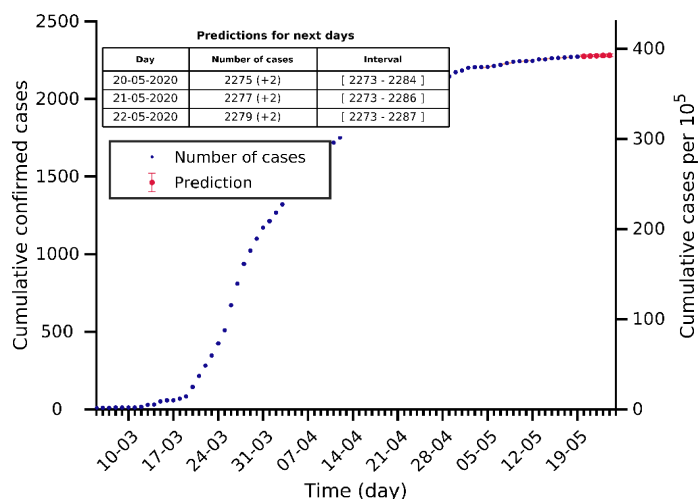
Asturias 19-05-2020. Population: 1.0M. Current cumulated incidence: 232/10⁵



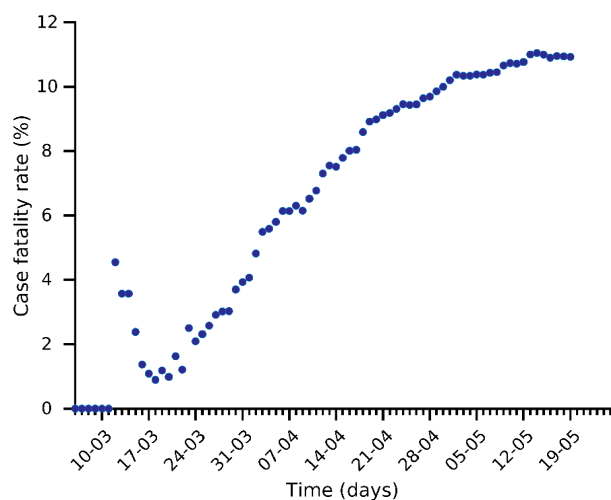
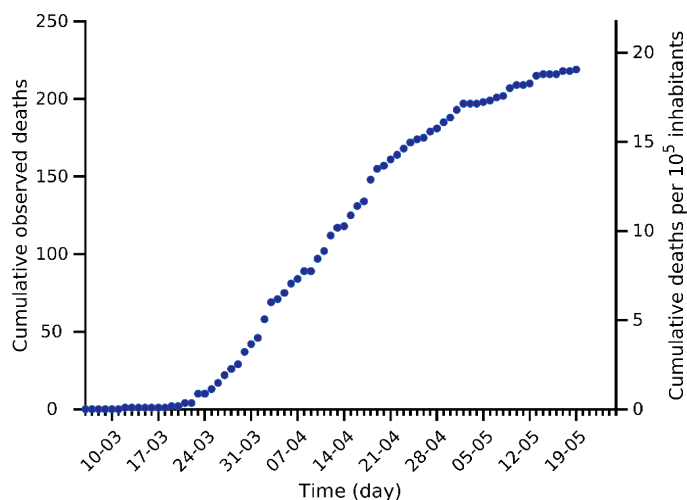
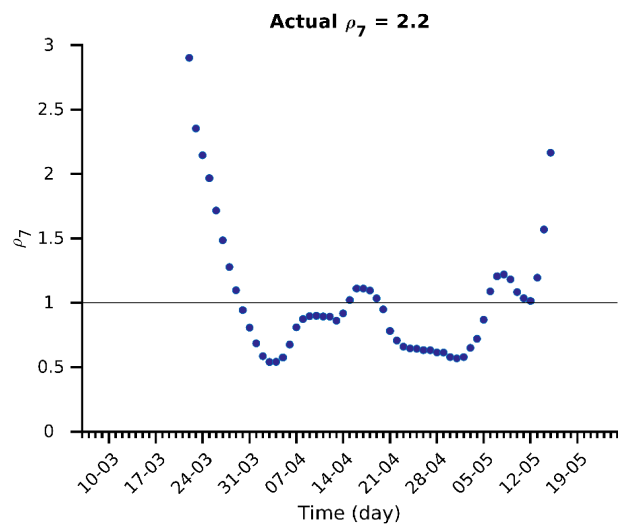
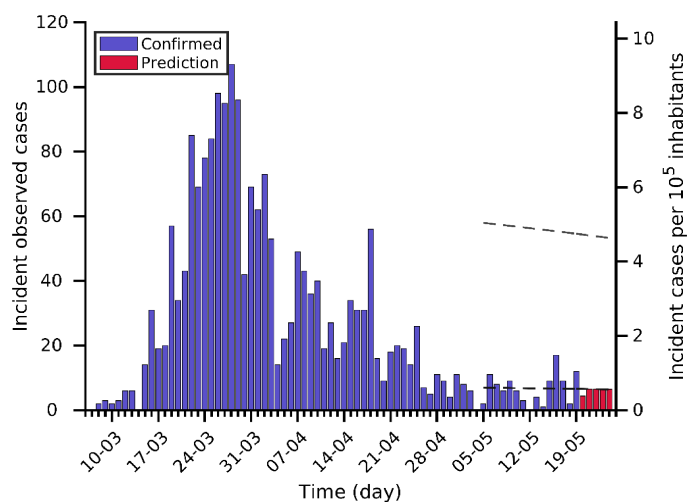
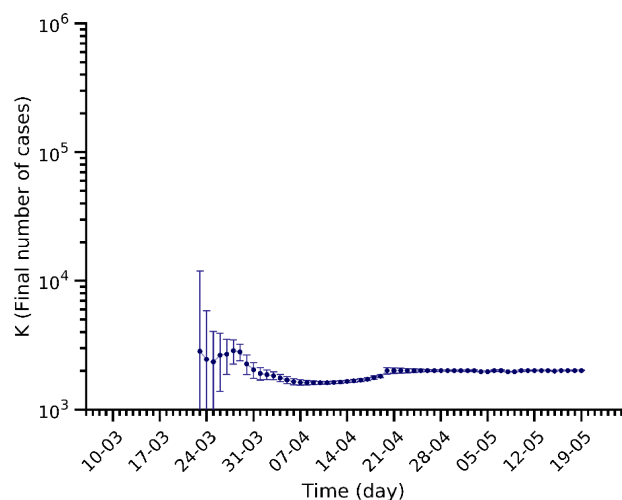
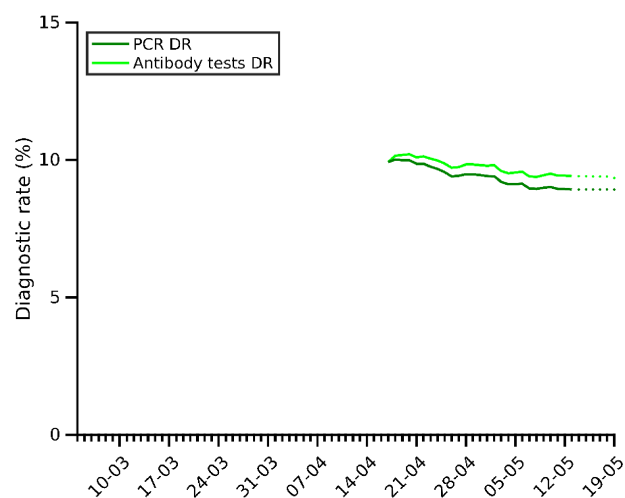
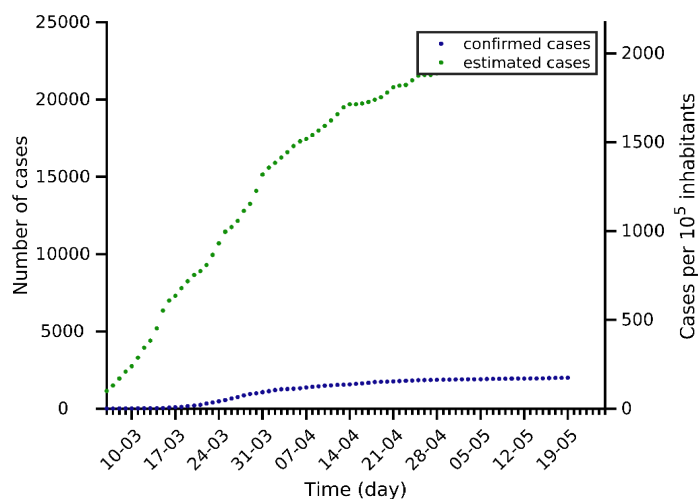
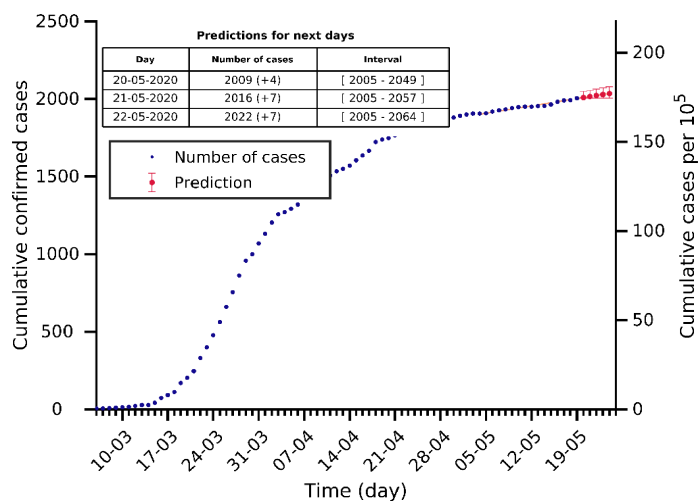
Canarias 19-05-2020. Population: 2.2M. Current cumulated incidence: 107/10⁵



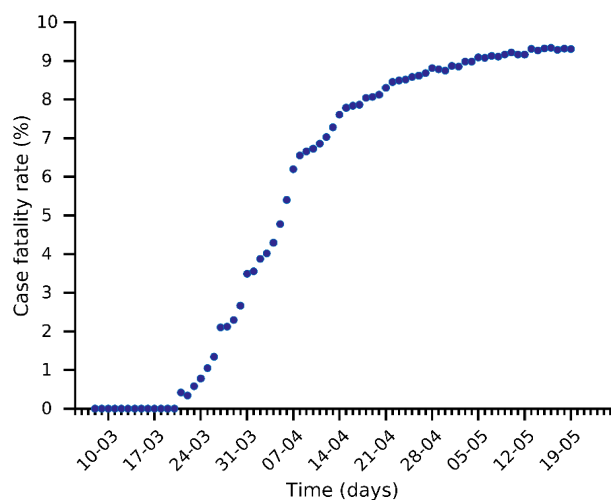
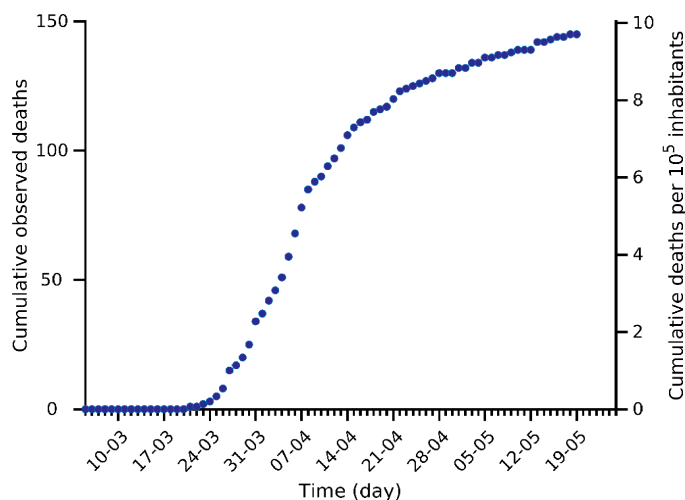
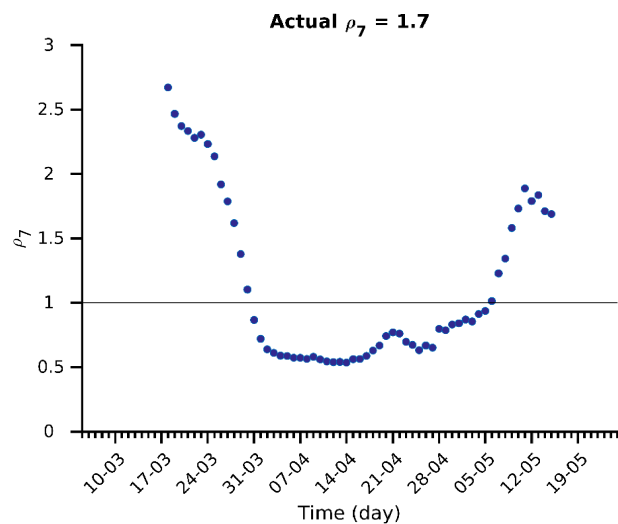
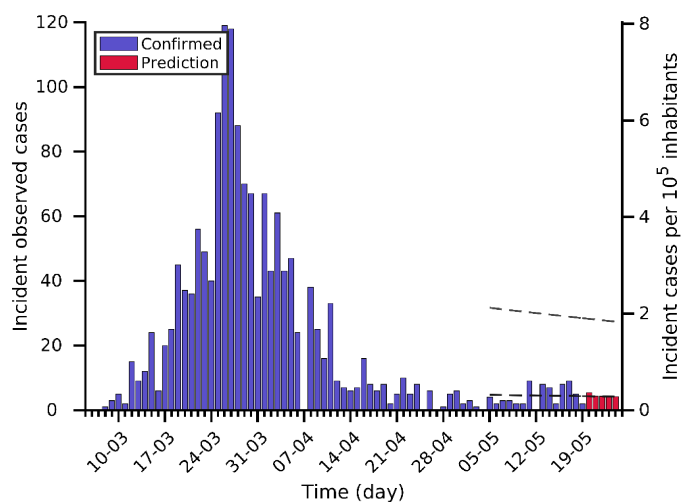
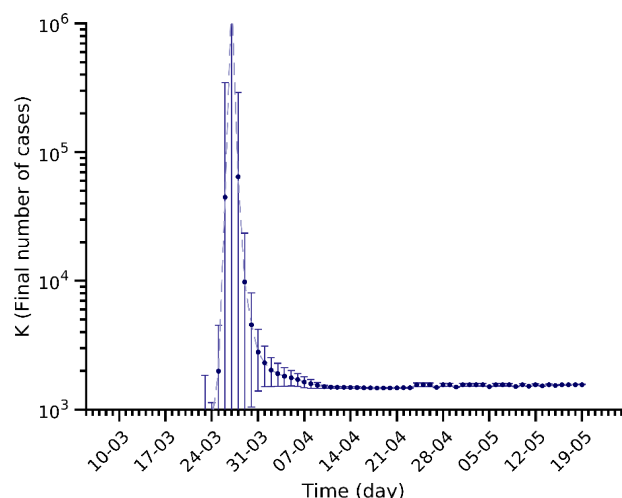
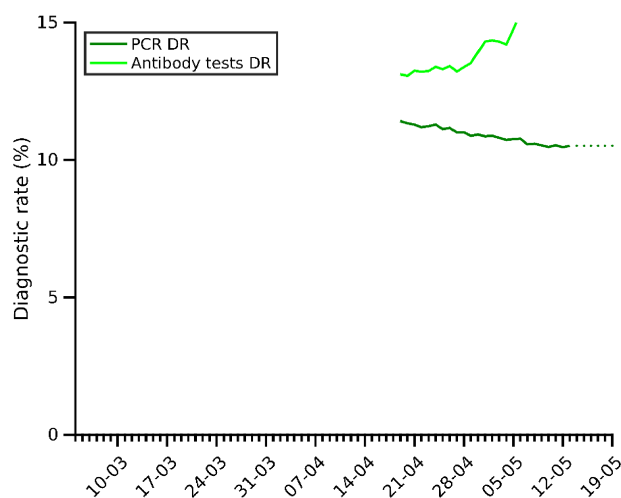
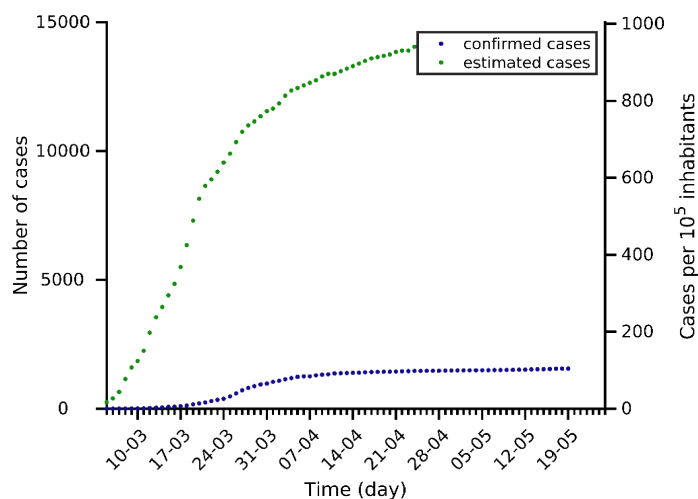
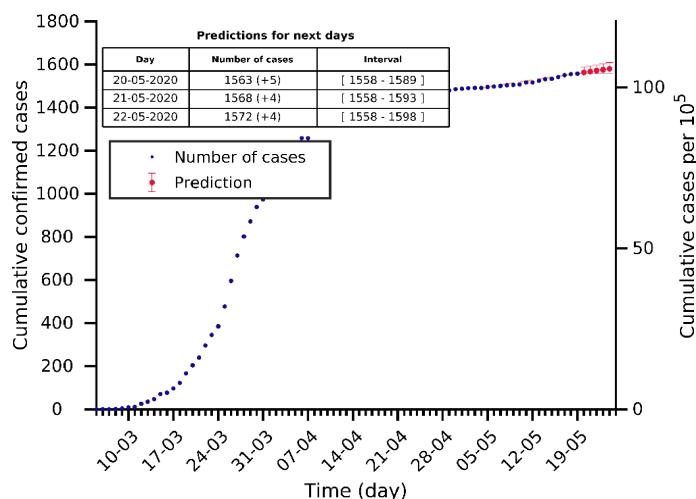
Cantabria 19-05-2020. Population: 0.6M. Current cumulated incidence: 391/10⁵



Baleares 19-05-2020. Population: 1.1M. Current cumulated incidence: 174/10⁵



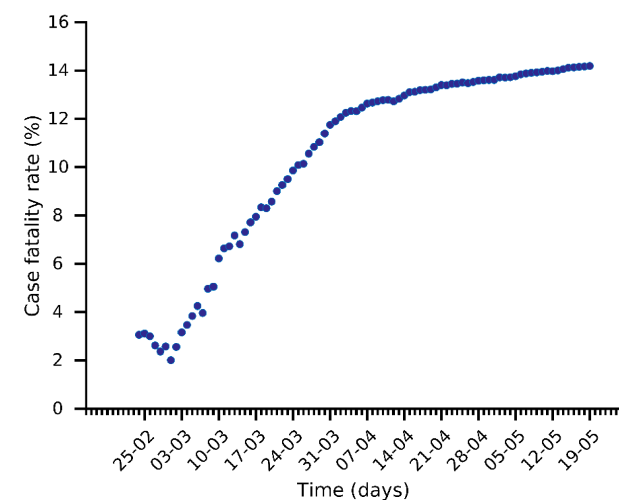
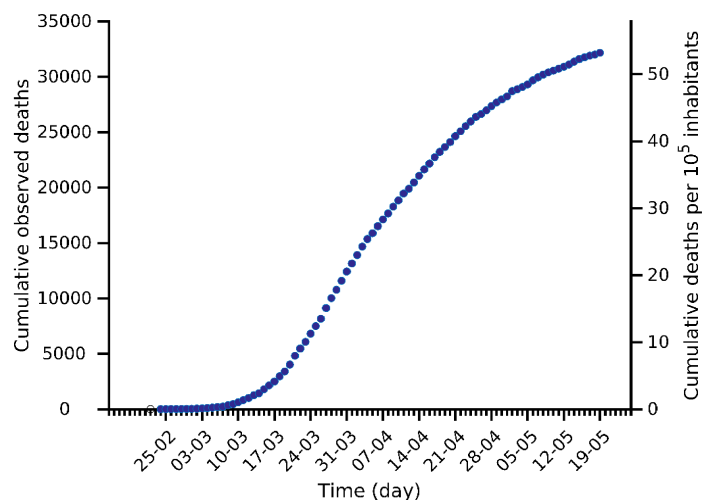
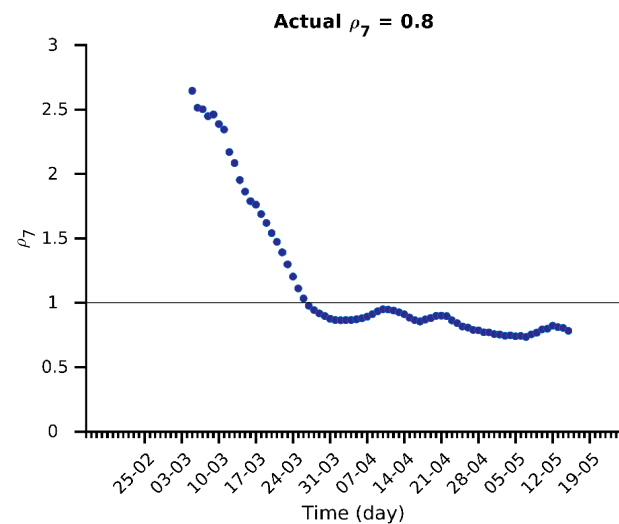
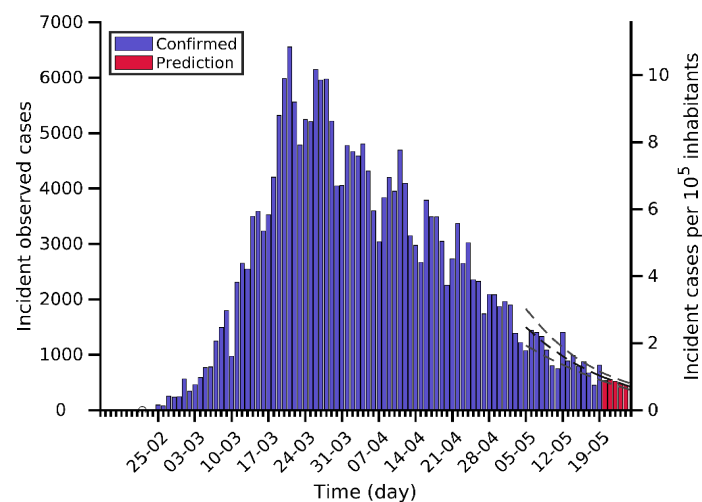
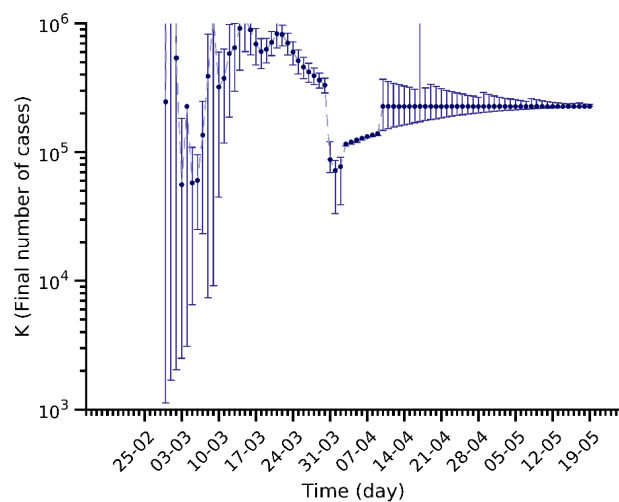
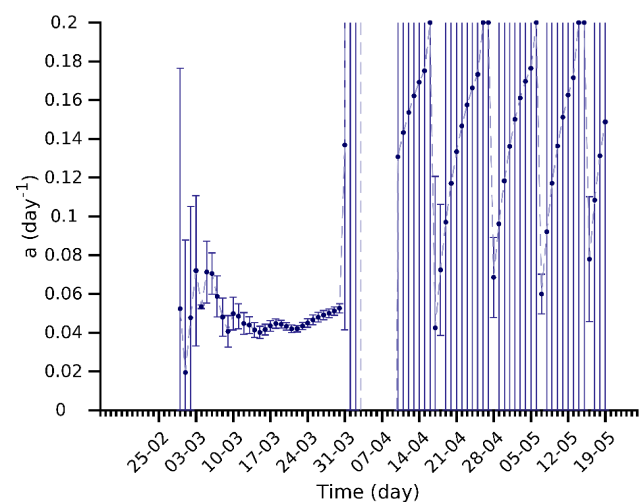
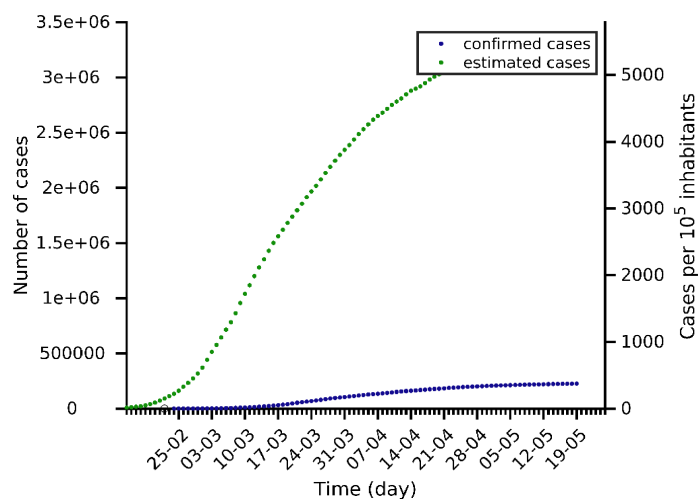
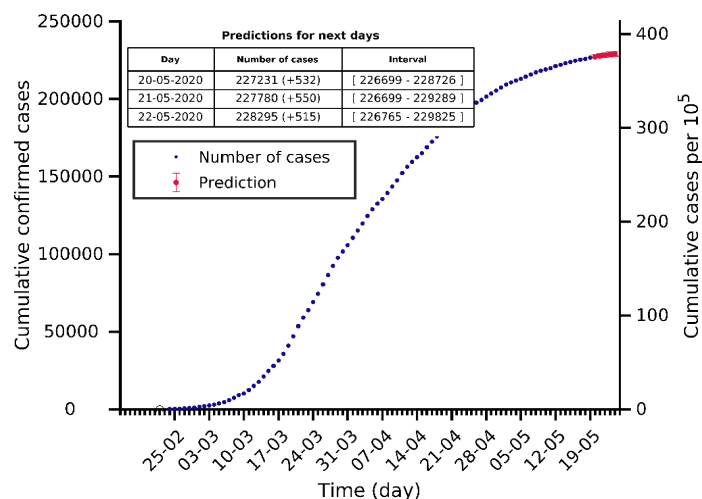
Murcia 19-05-2020. Population: 1.5M. Current cumulated incidence: 104/10⁵



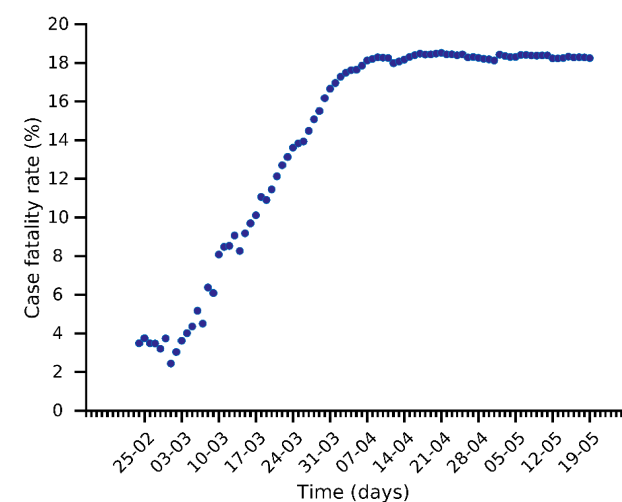
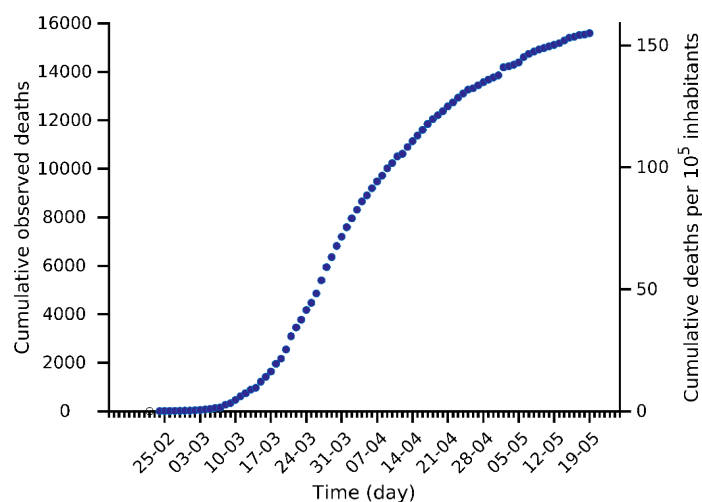
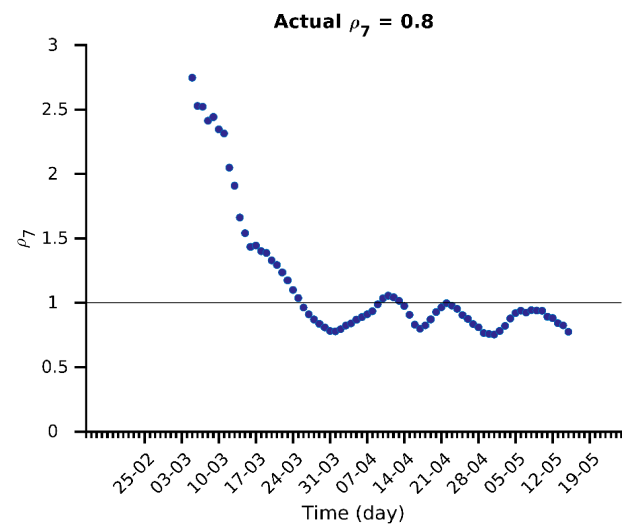
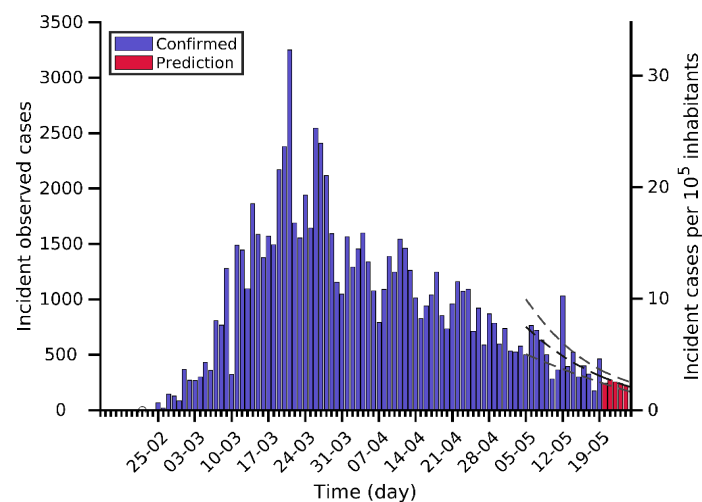
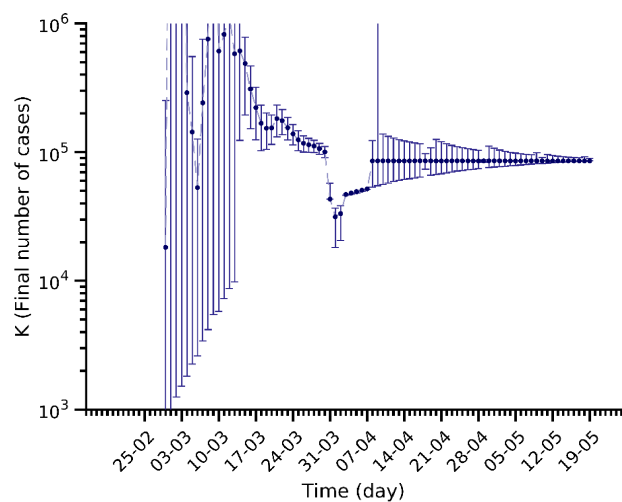
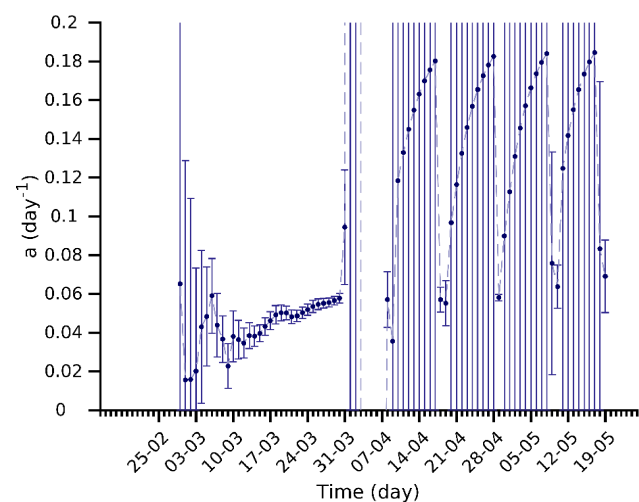
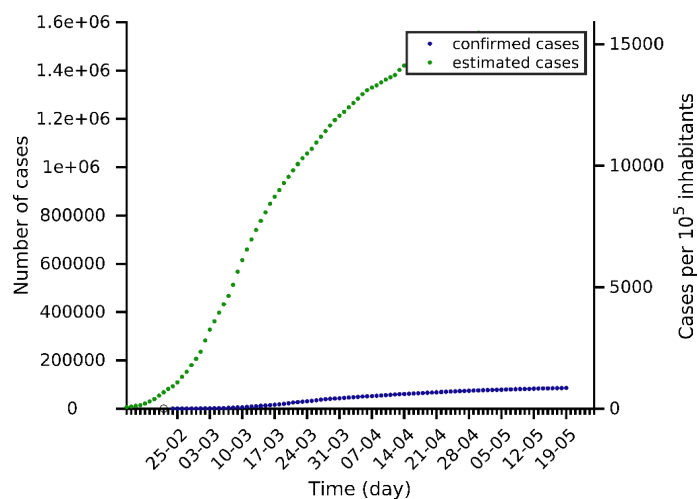
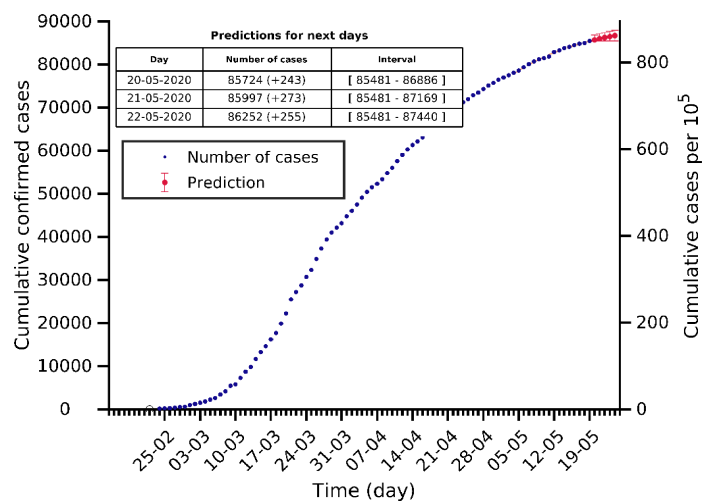
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

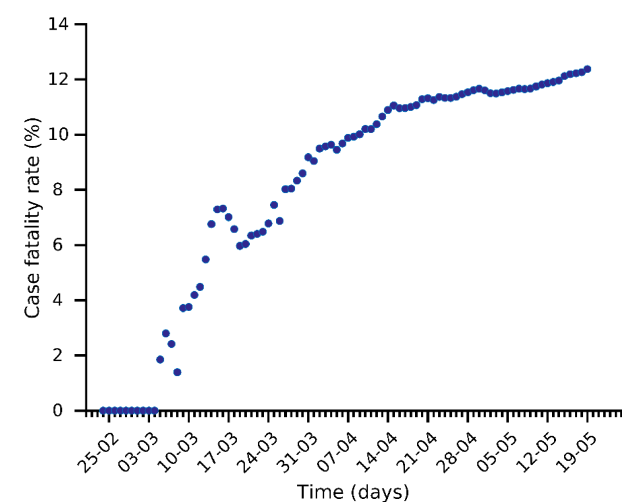
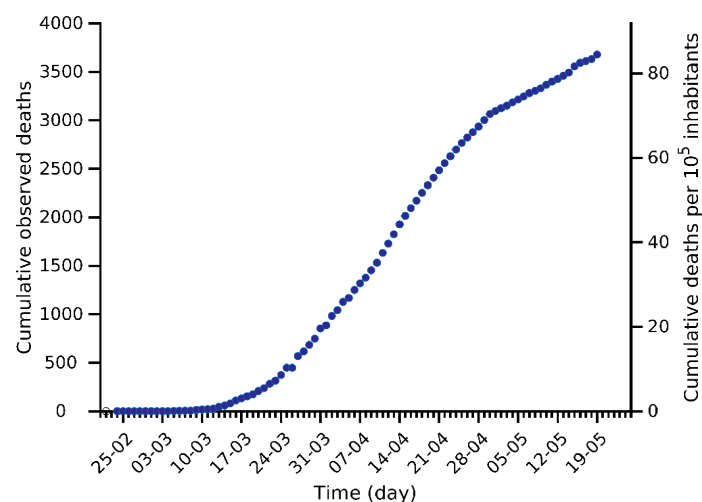
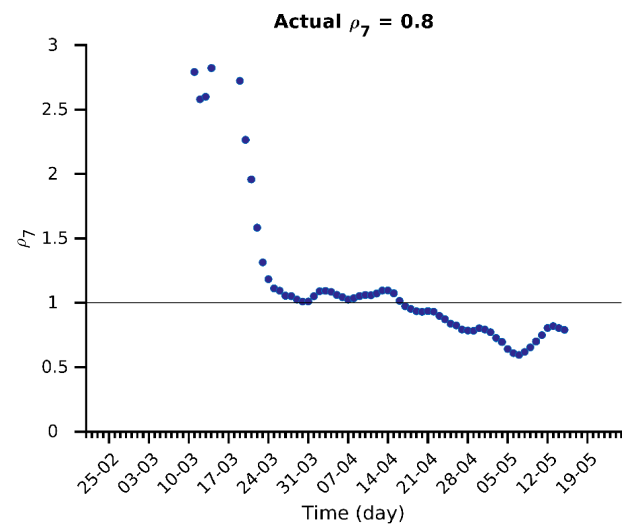
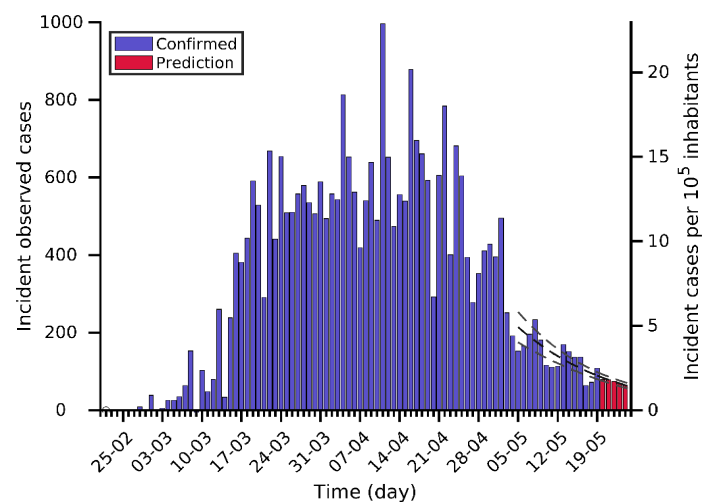
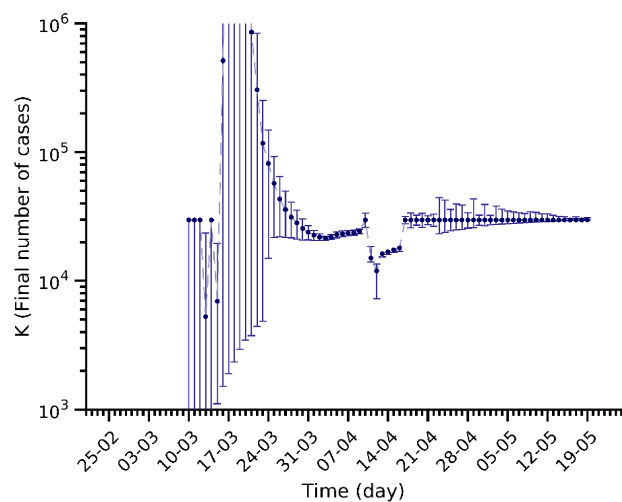
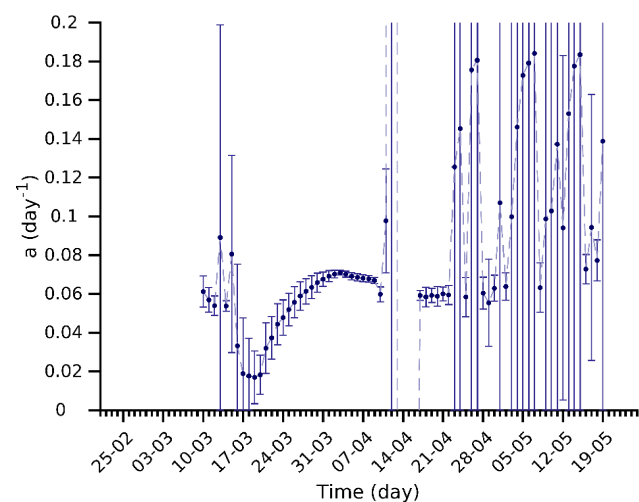
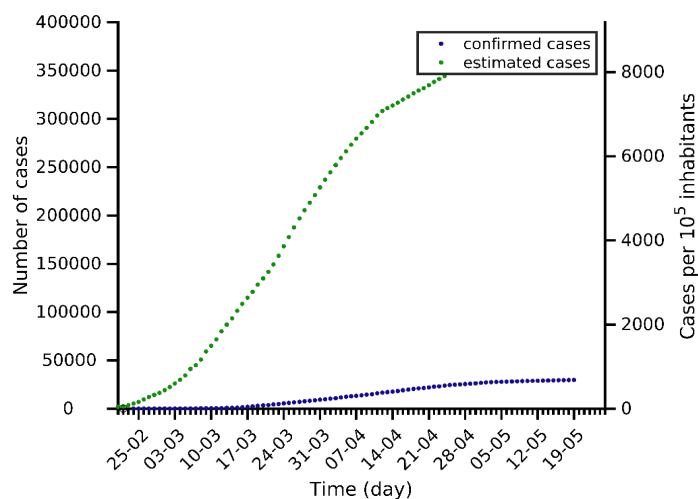
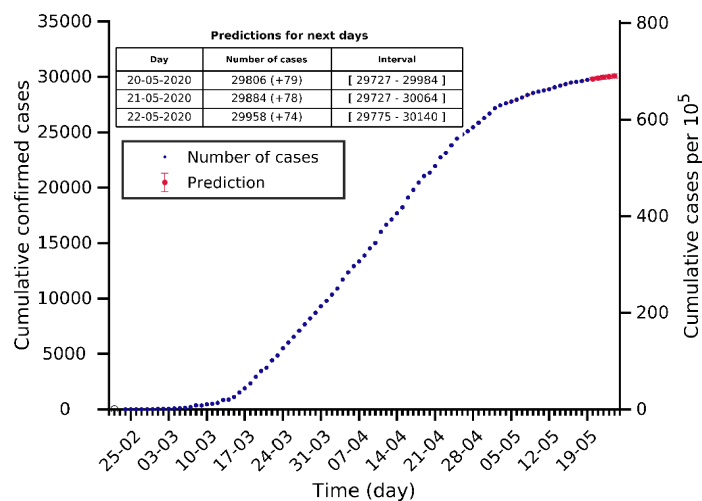
Italy 19-05-2020. Population: 60.5M. Current cumulated incidence: 375/10⁵



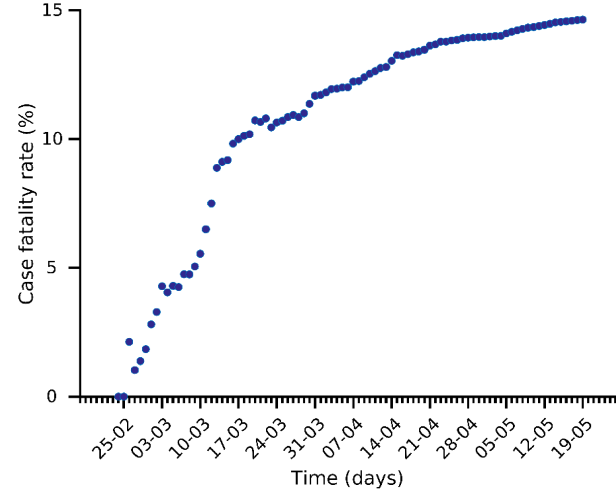
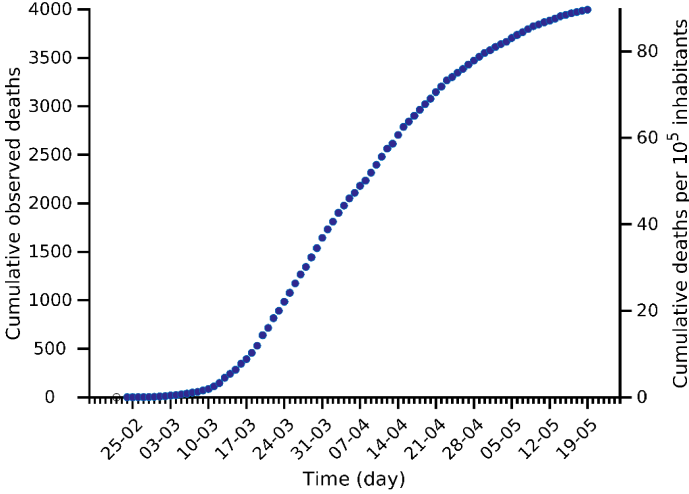
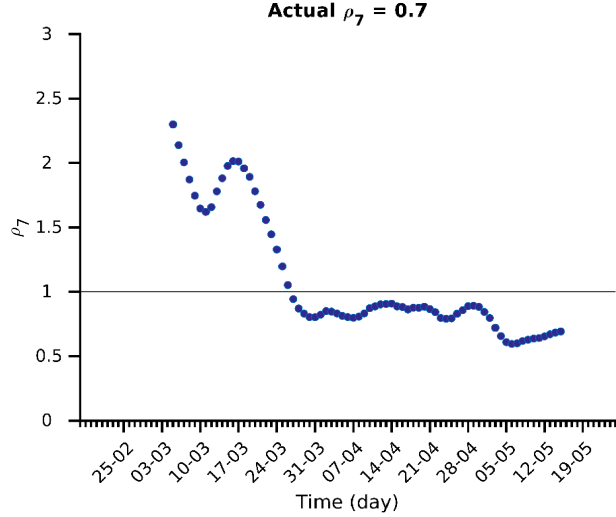
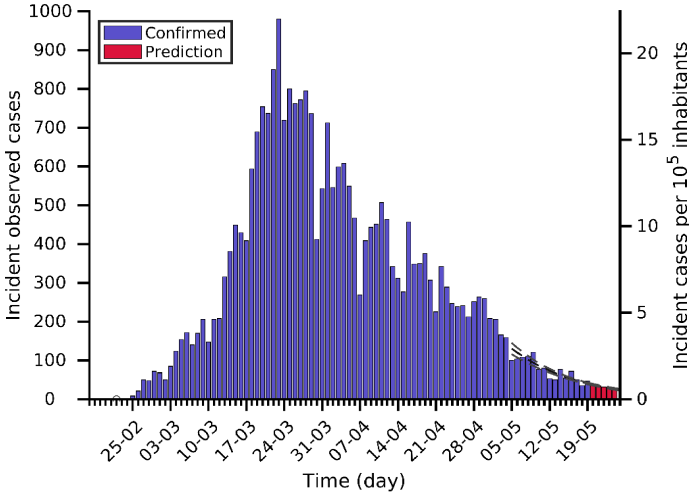
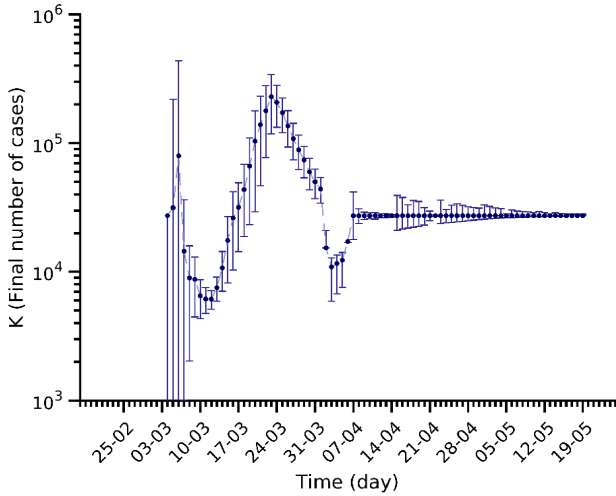
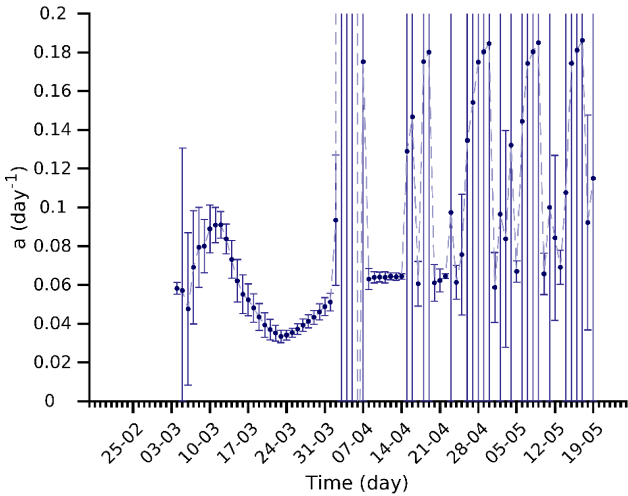
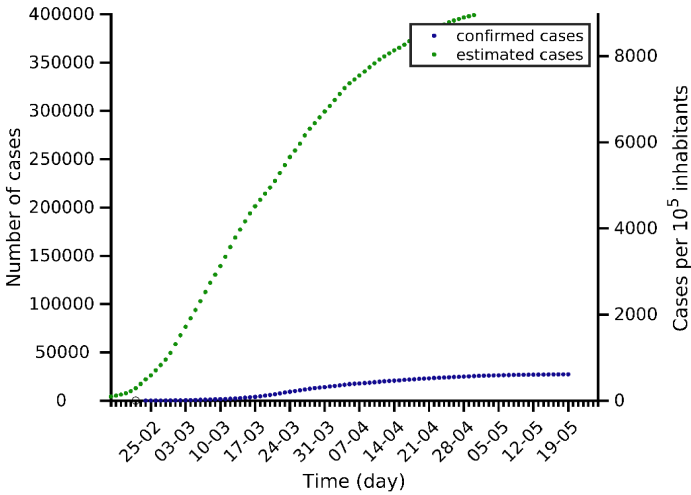
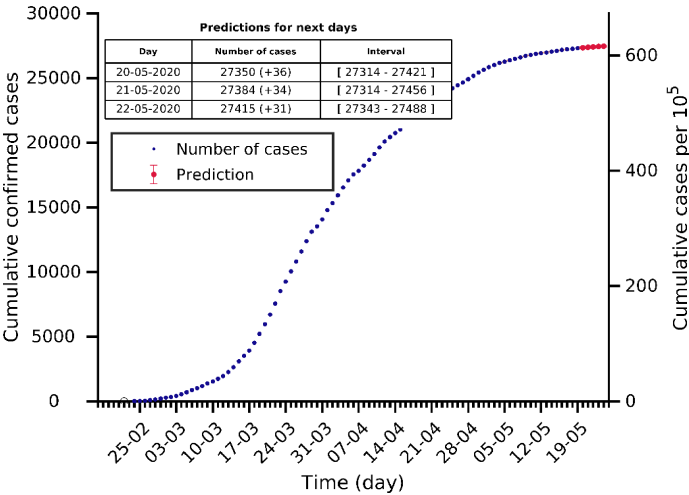
Lombardia 19-05-2020. Population: 10.1M. Current cumulated incidence: 850/10⁵



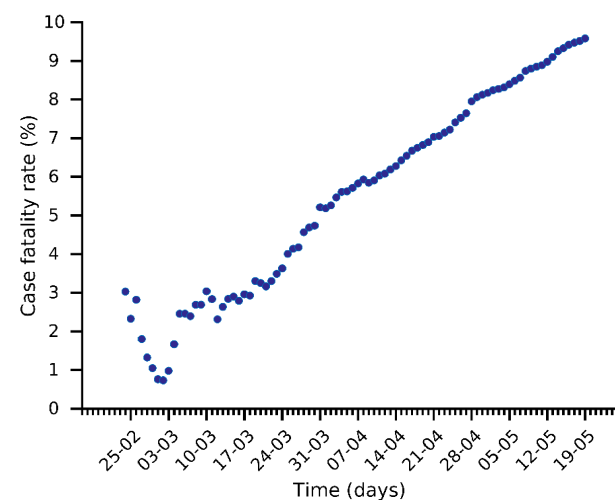
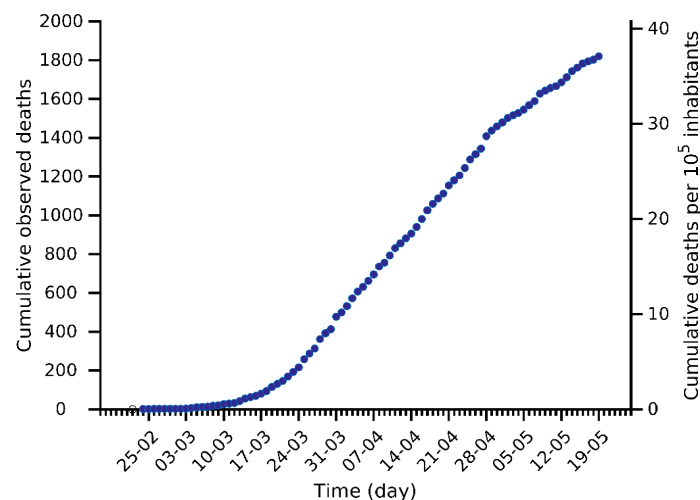
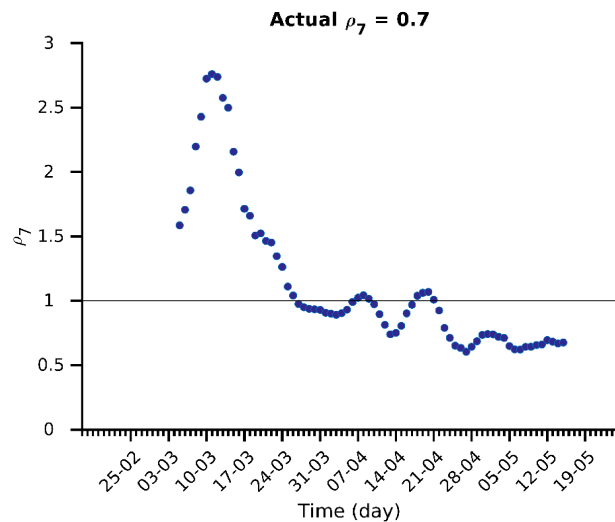
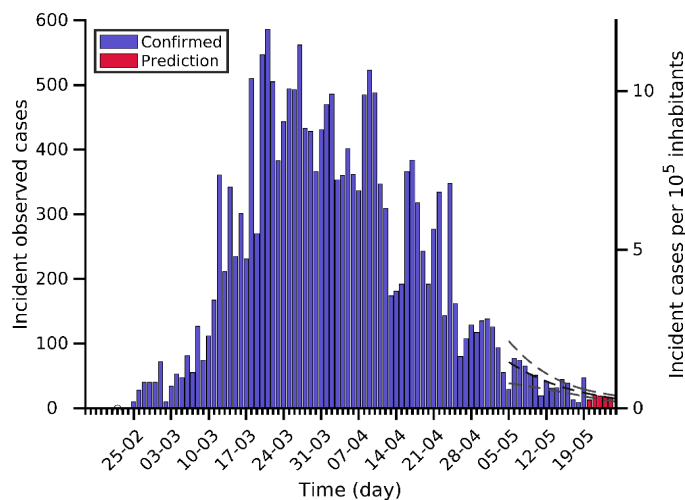
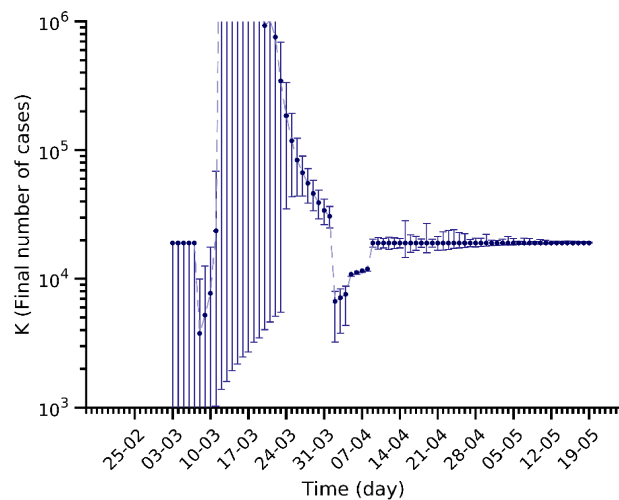
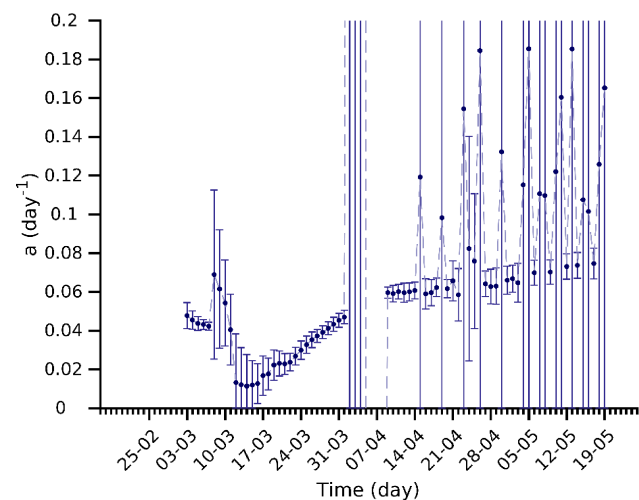
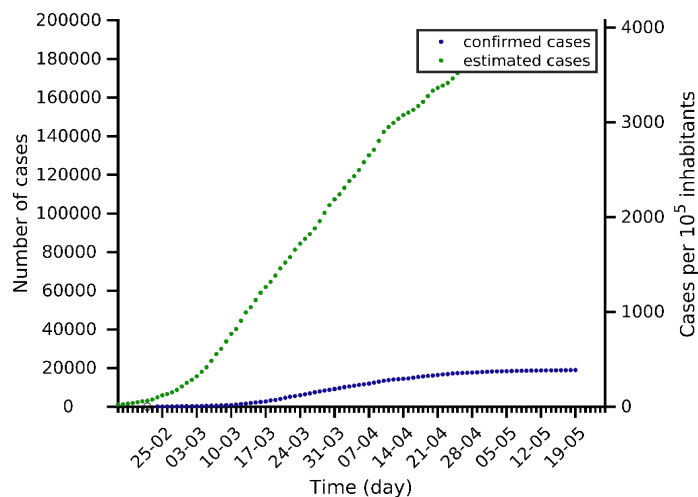
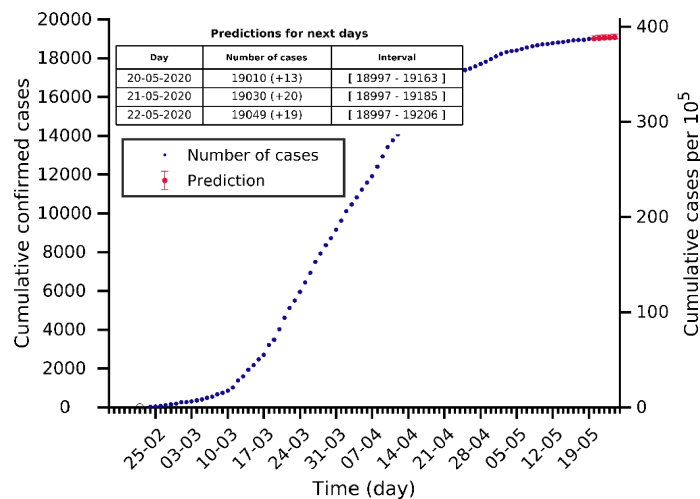
Piemonte 19-05-2020. Population: 4.4M. Current cumulated incidence: 682/10⁵



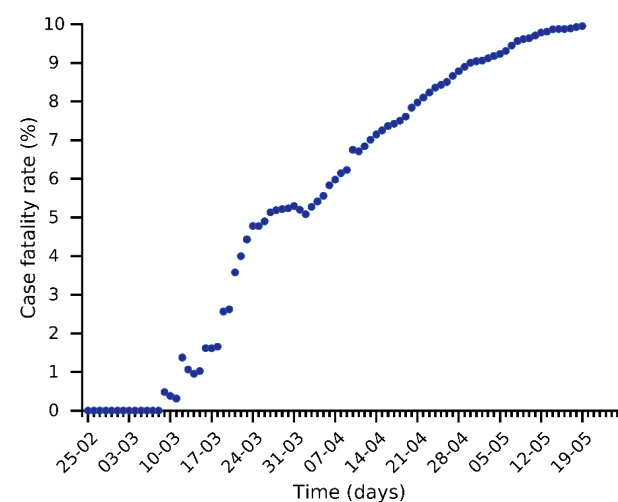
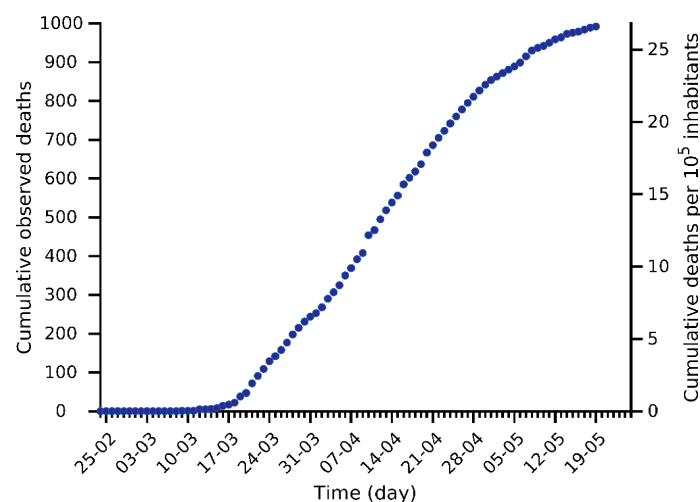
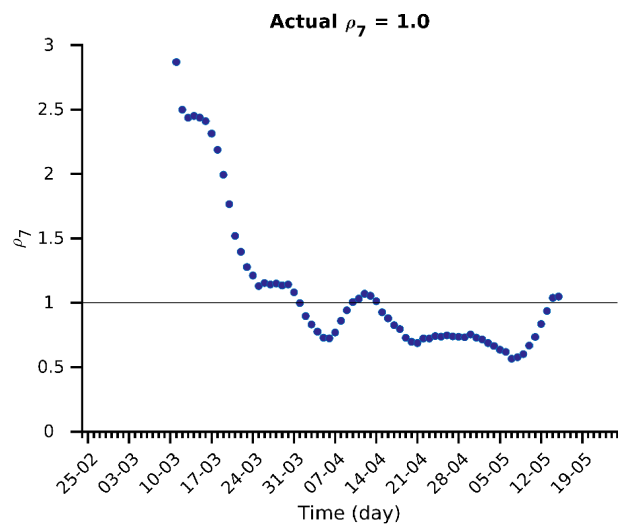
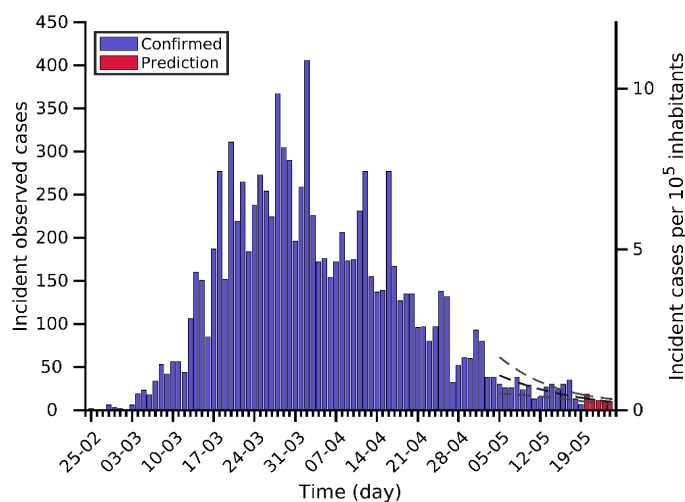
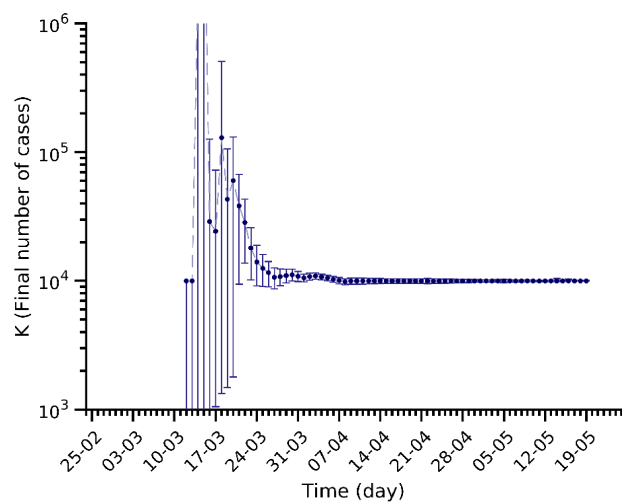
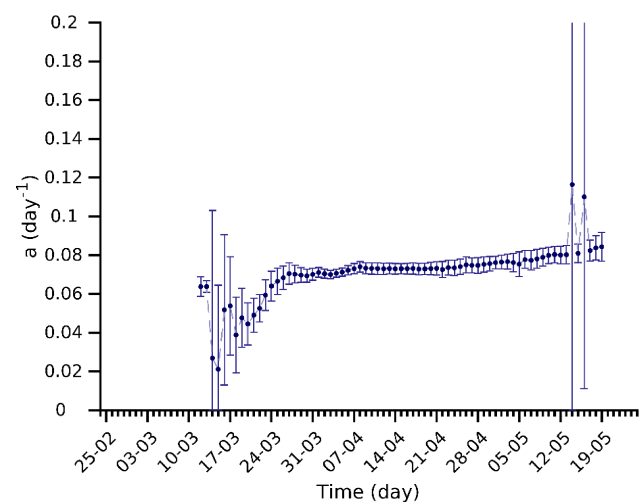
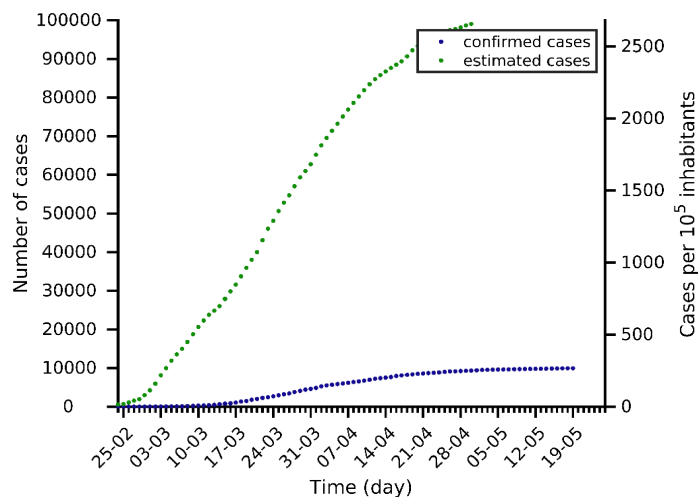
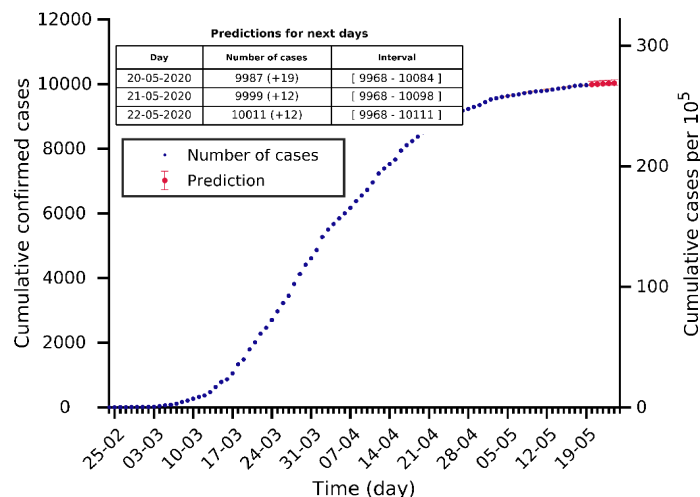
Emilia Romagna 19-05-2020. Population: 4.5M. Current cumulated incidence: 613/100000



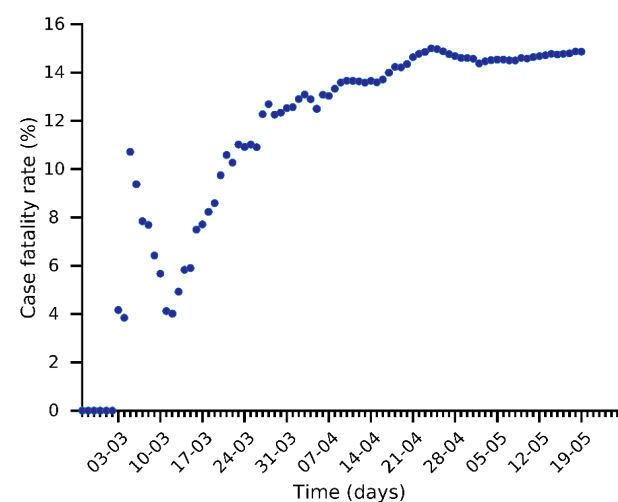
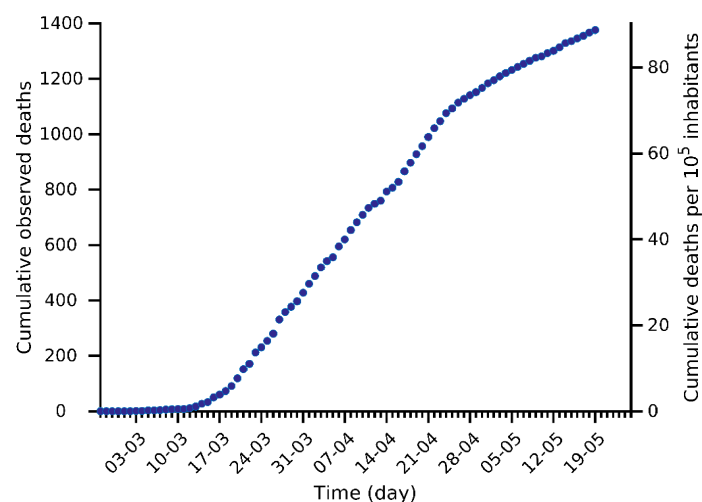
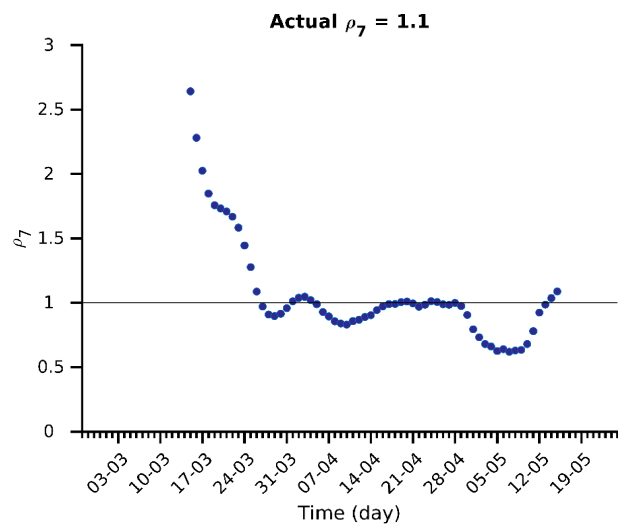
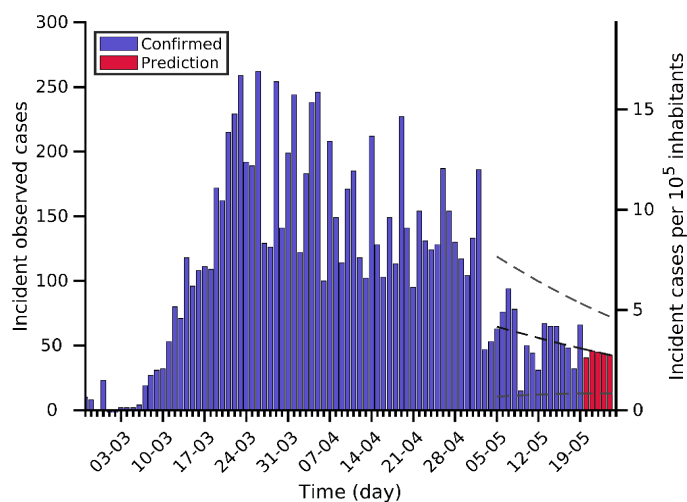
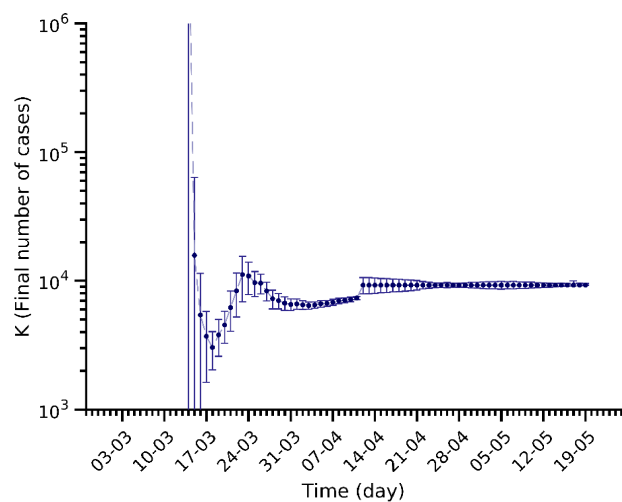
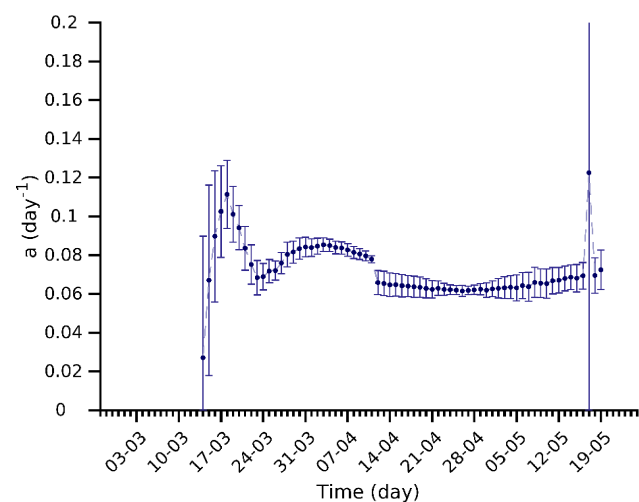
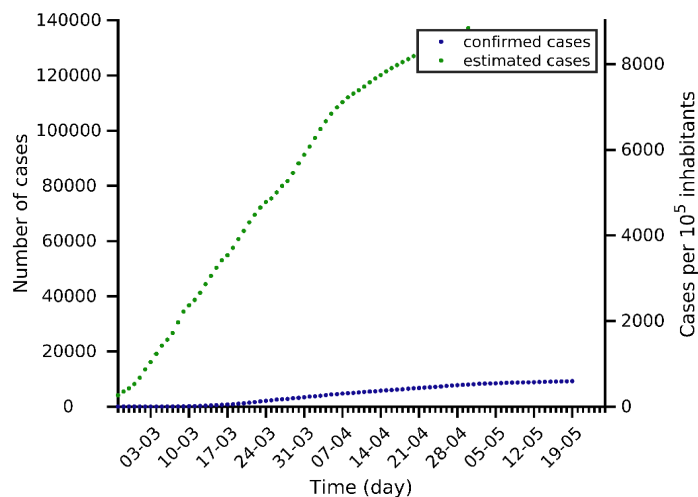
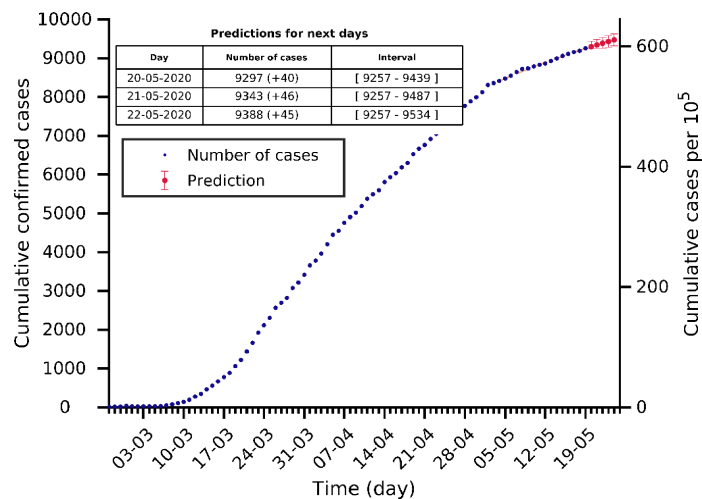
Veneto 19-05-2020. Population: 4.9M. Current cumulated incidence: 387/10⁵



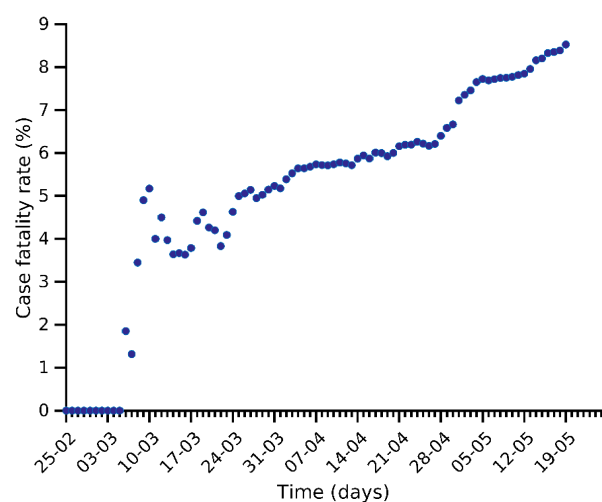
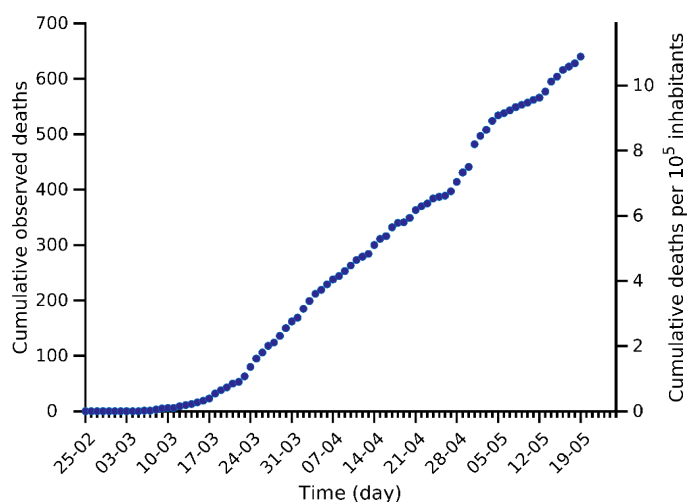
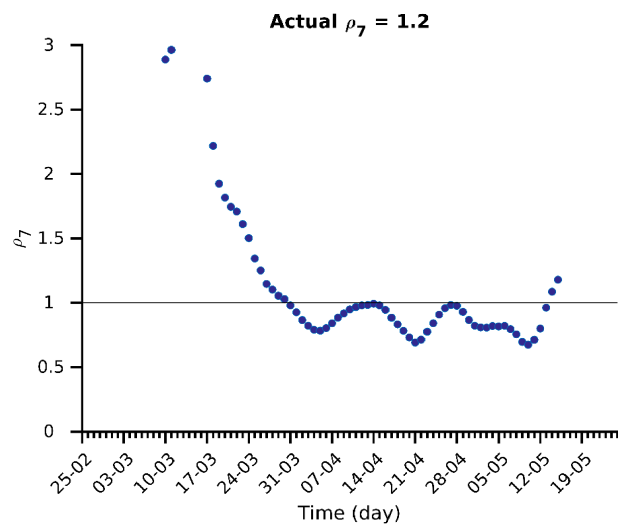
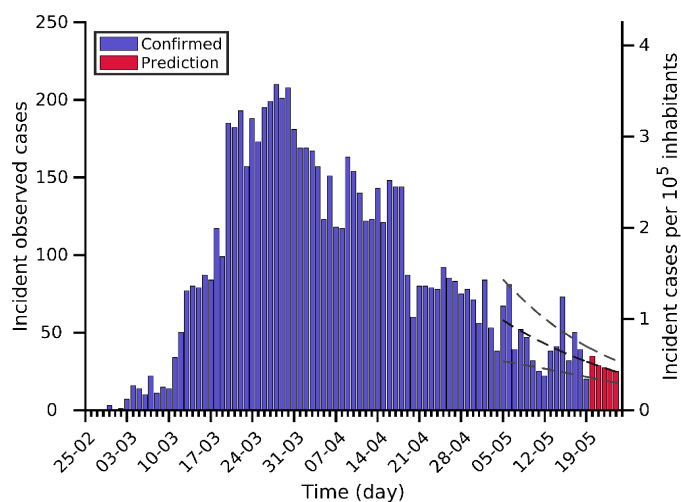
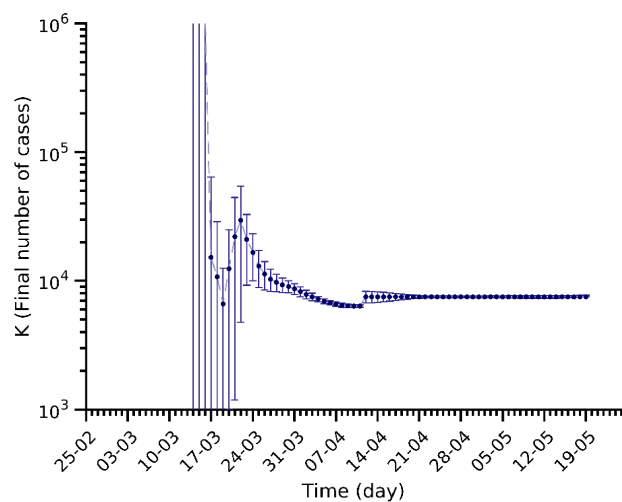
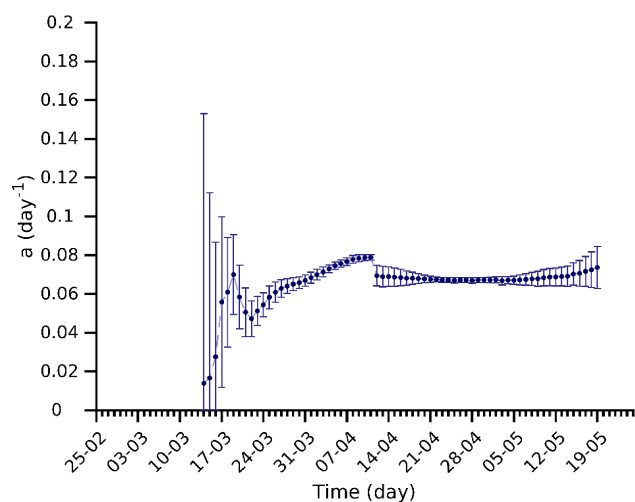
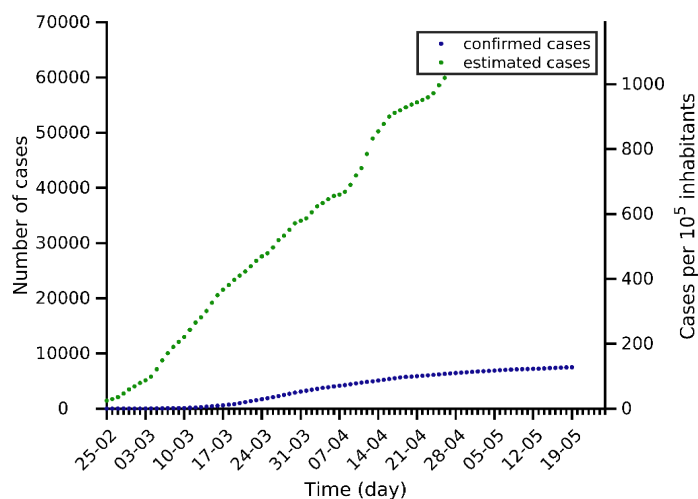
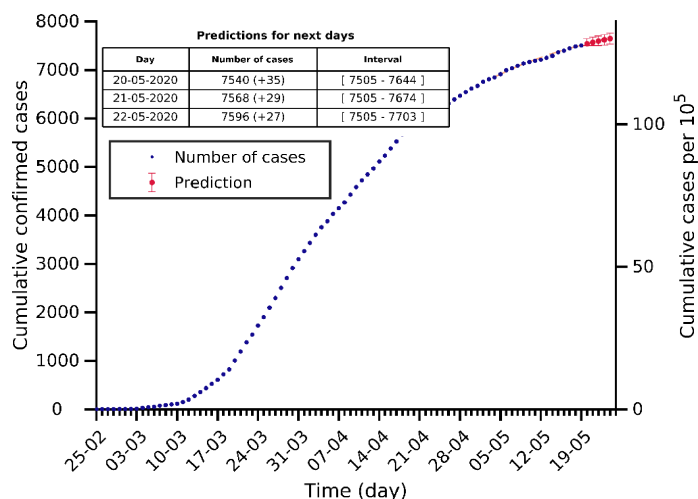
Toscana 19-05-2020. Population: 3.7M. Current cumulated incidence: 267/10⁵



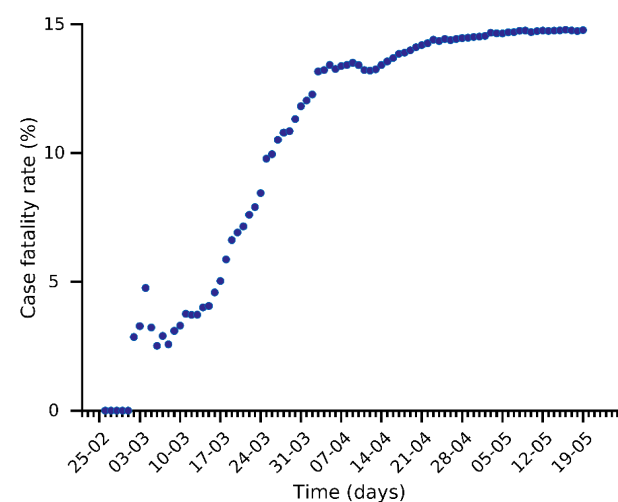
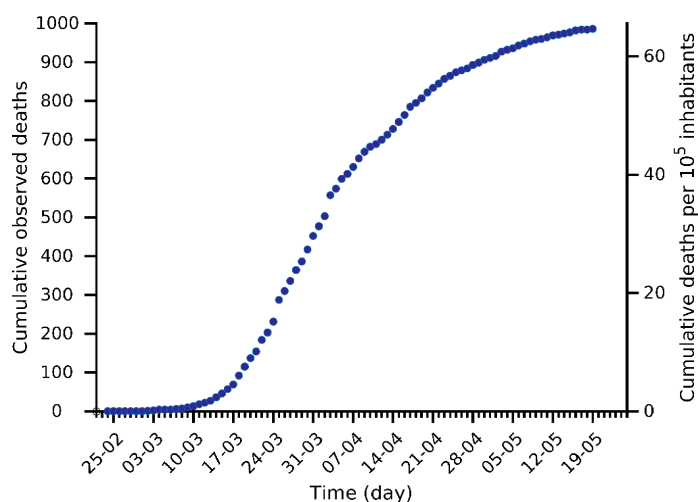
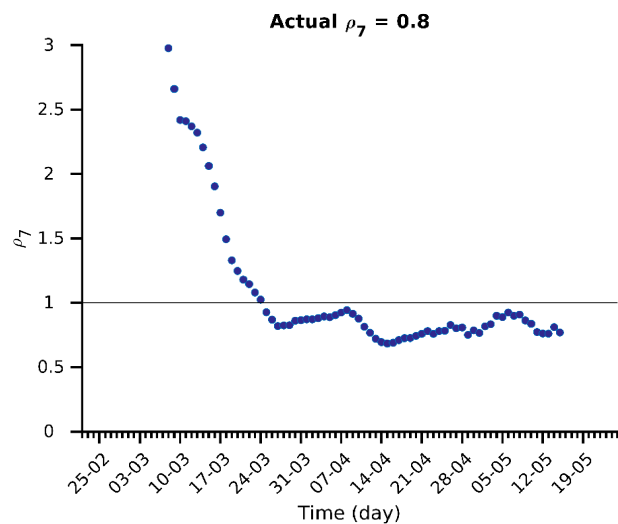
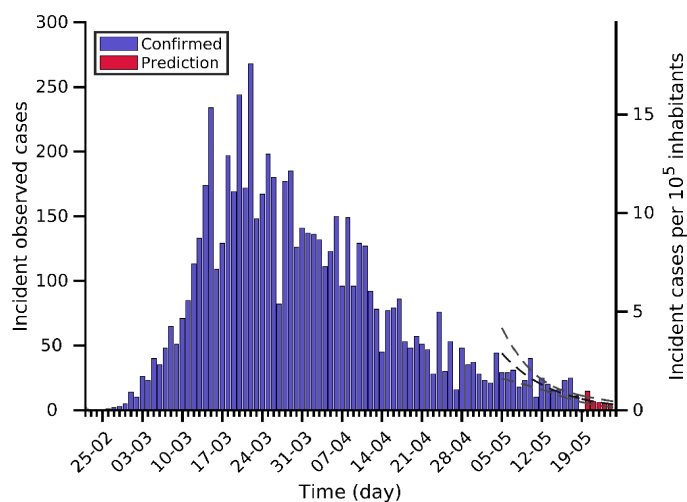
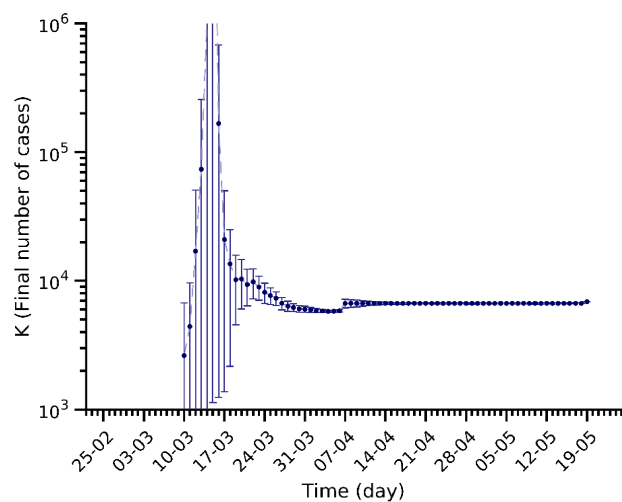
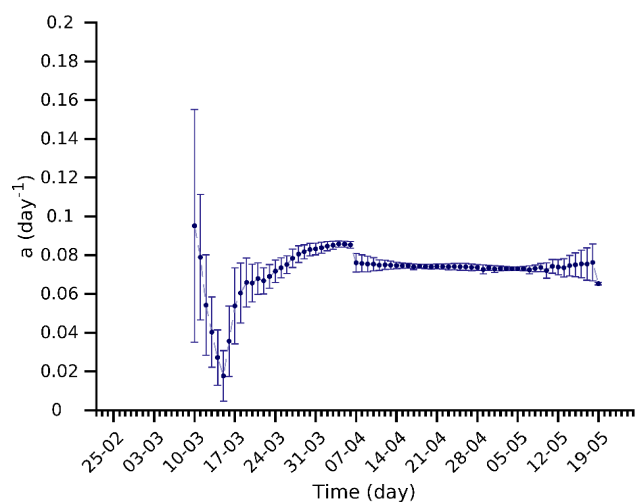
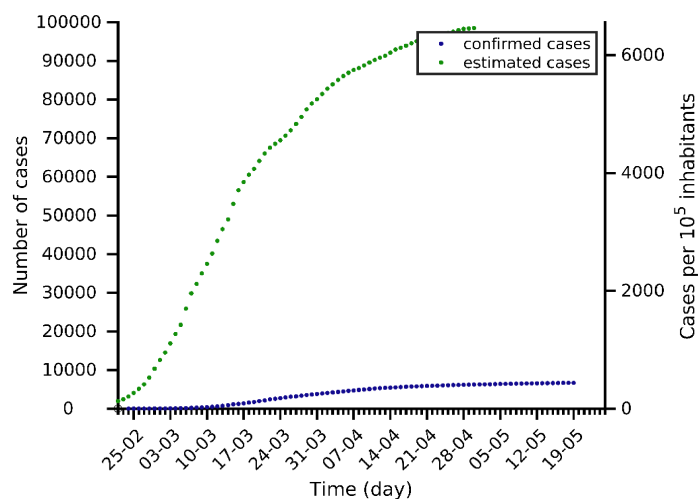
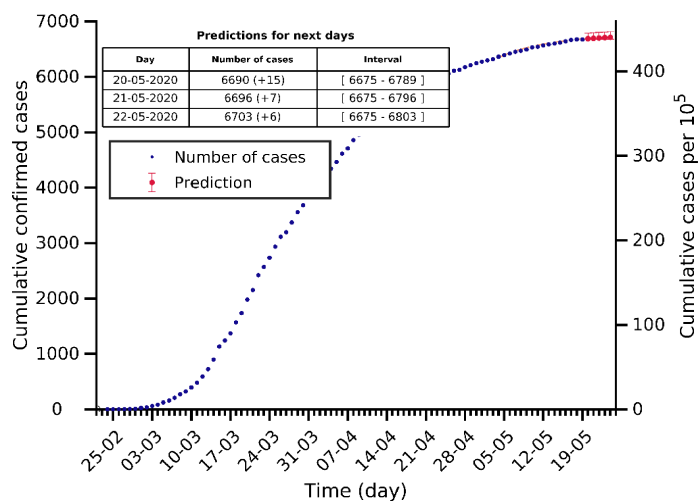
Liguria 19-05-2020. Population: 1.6M. Current cumulated incidence: 597/10⁵



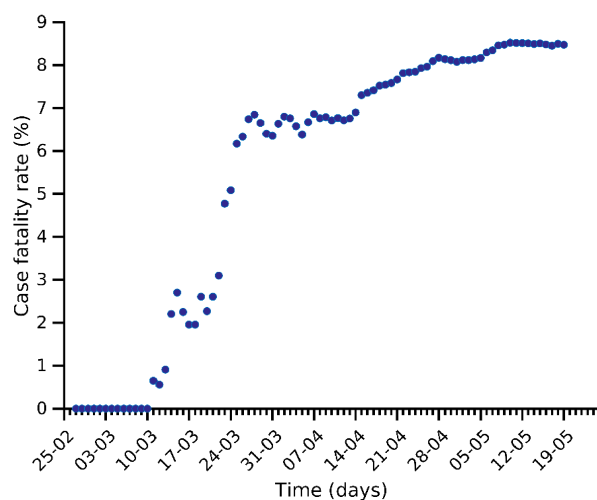
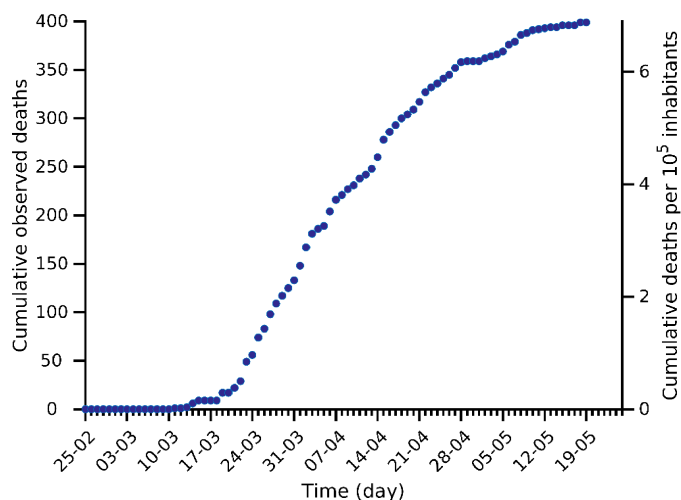
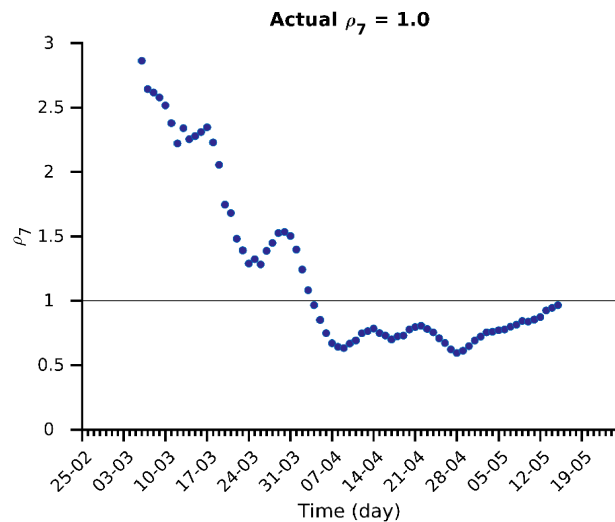
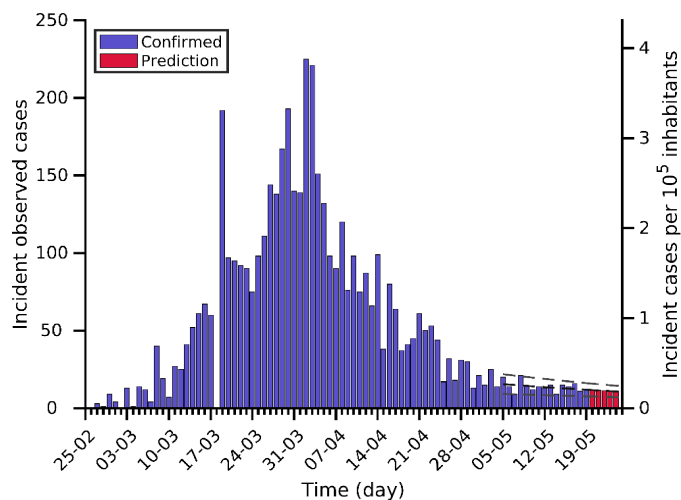
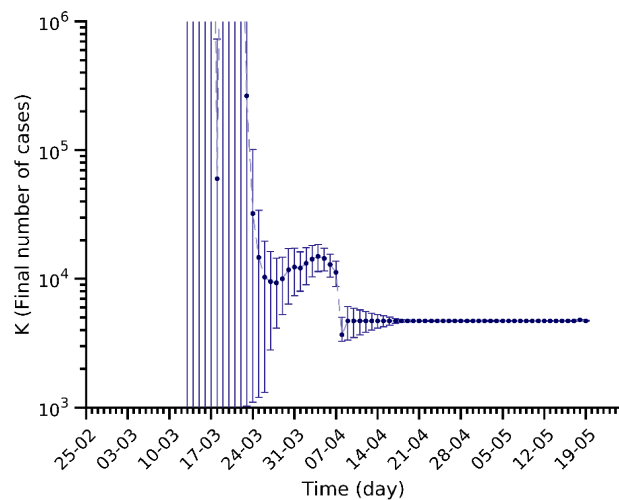
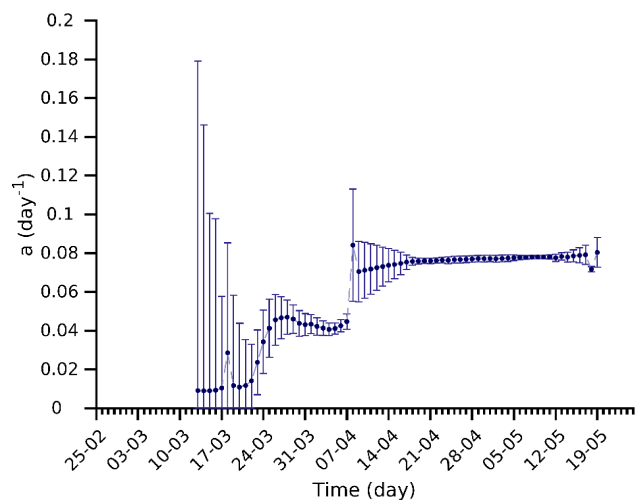
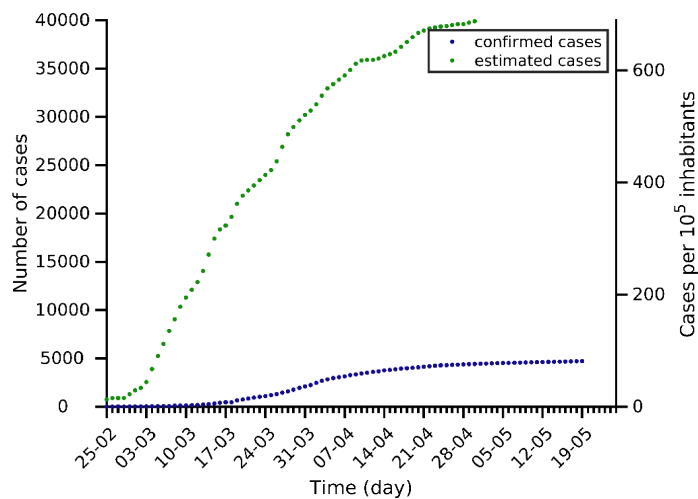
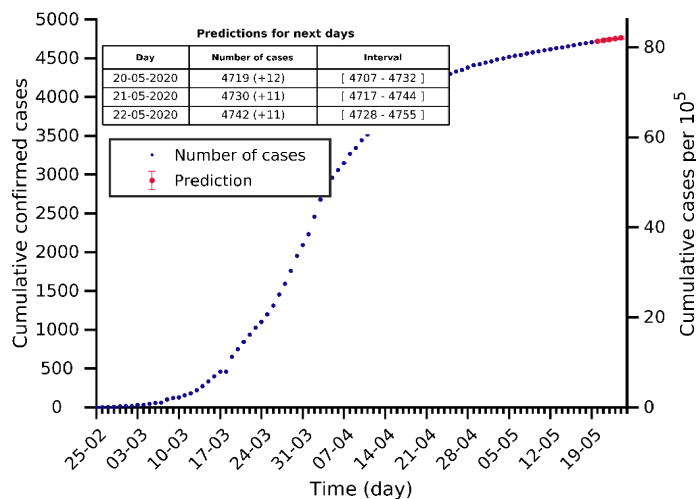
Lazio 19-05-2020. Population: 5.9M. Current cumulated incidence: 128/10⁵



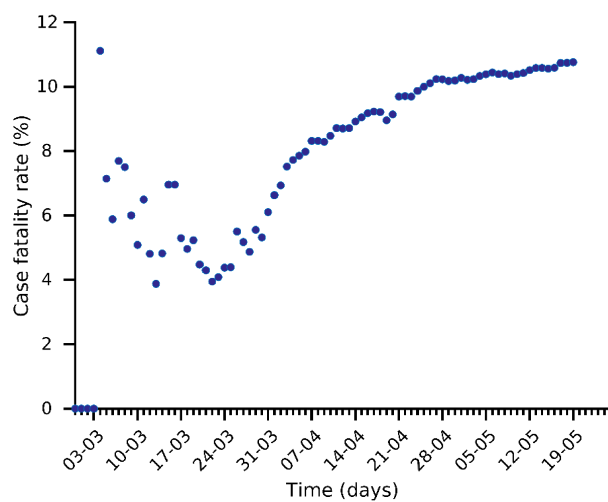
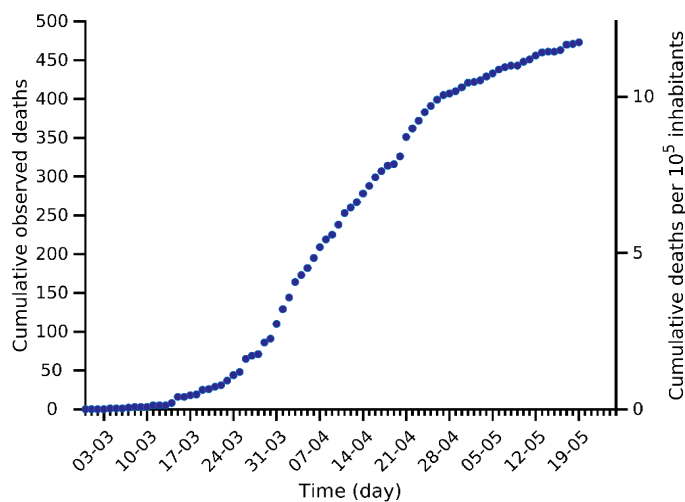
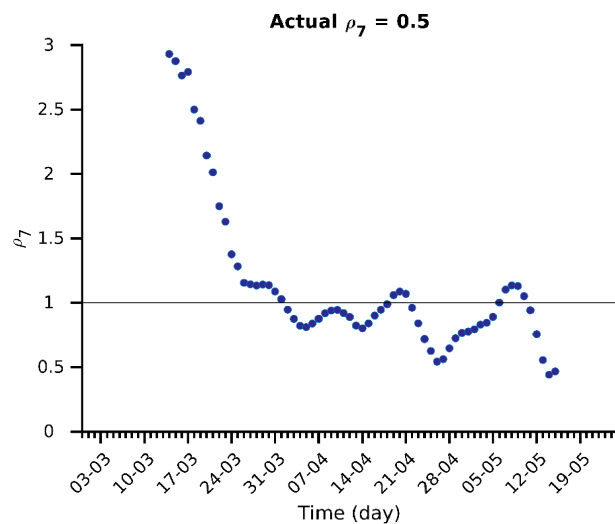
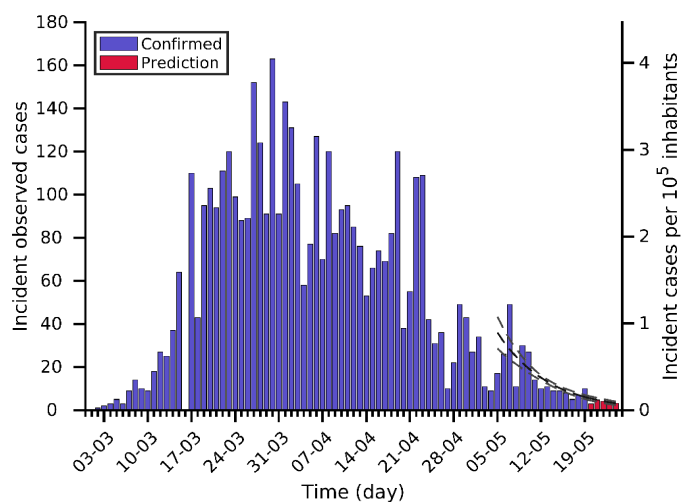
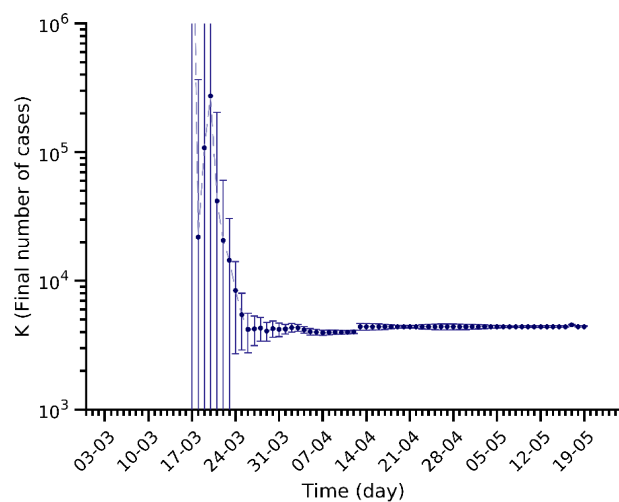
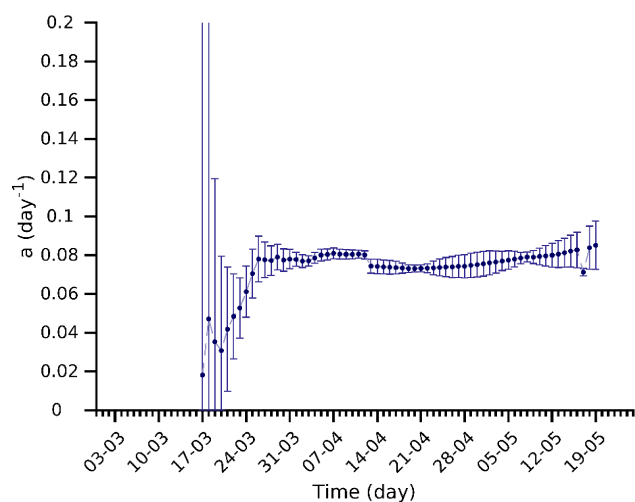
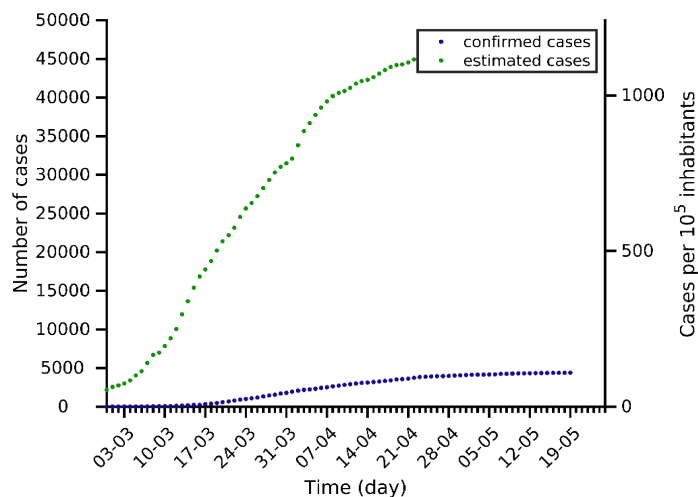
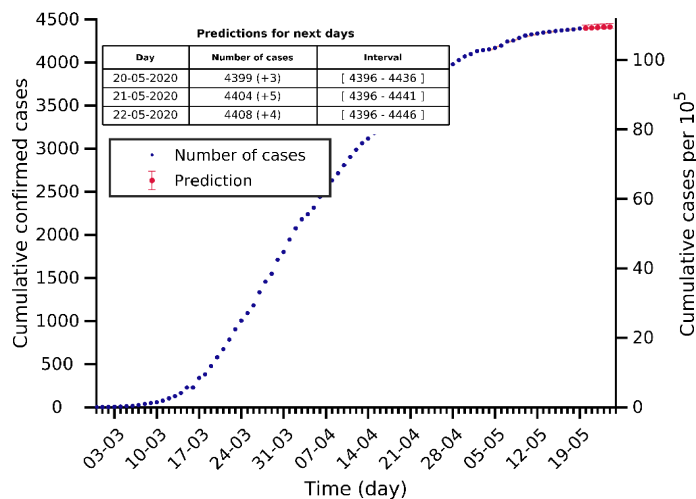
Marche 19-05-2020. Population: 1.5M. Current cumulated incidence: 438/10⁵



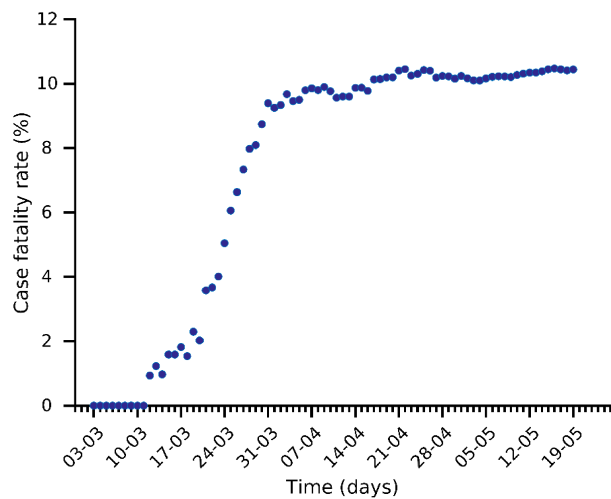
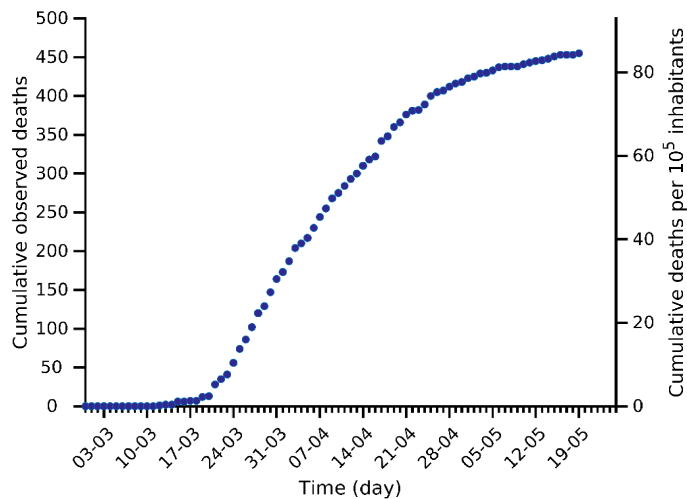
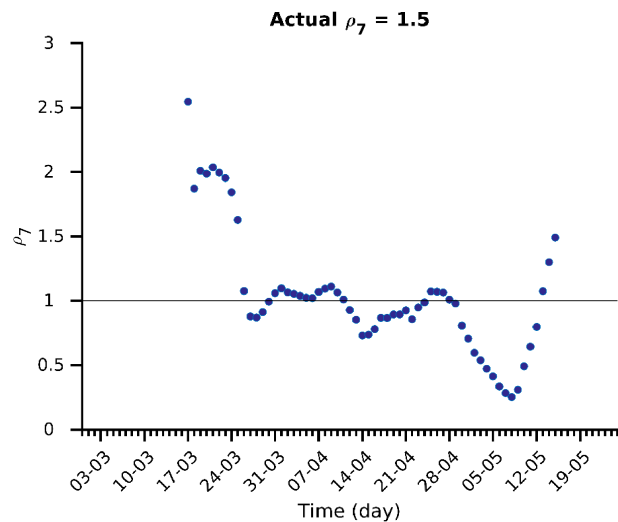
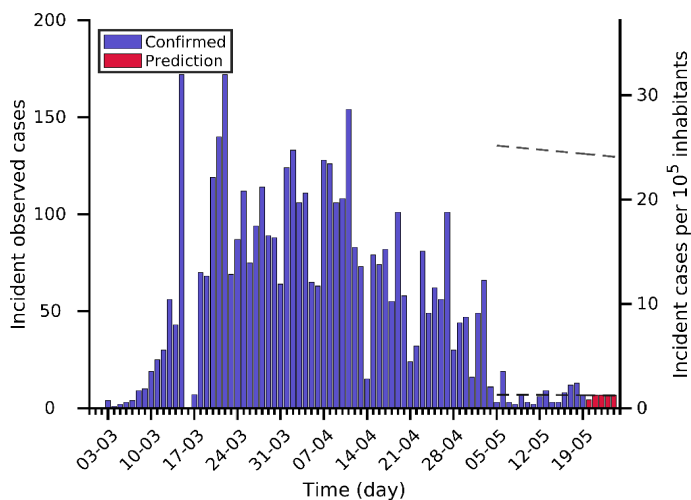
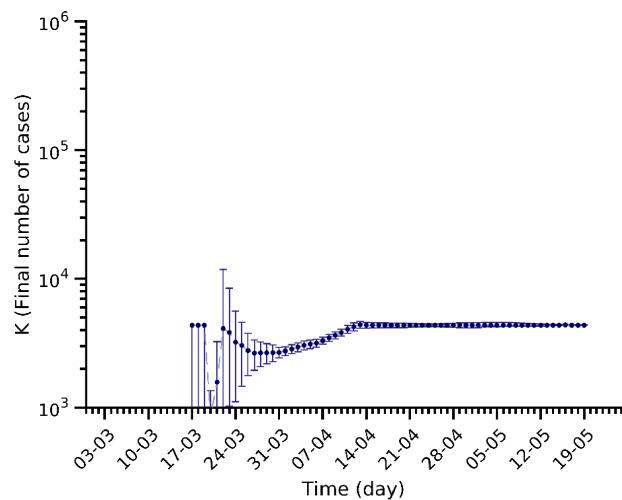
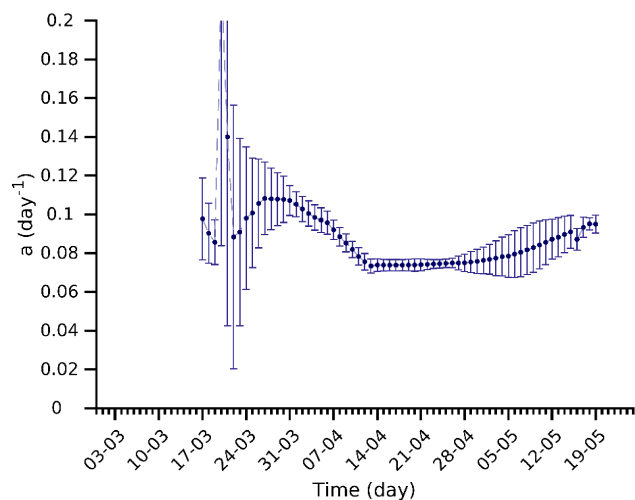
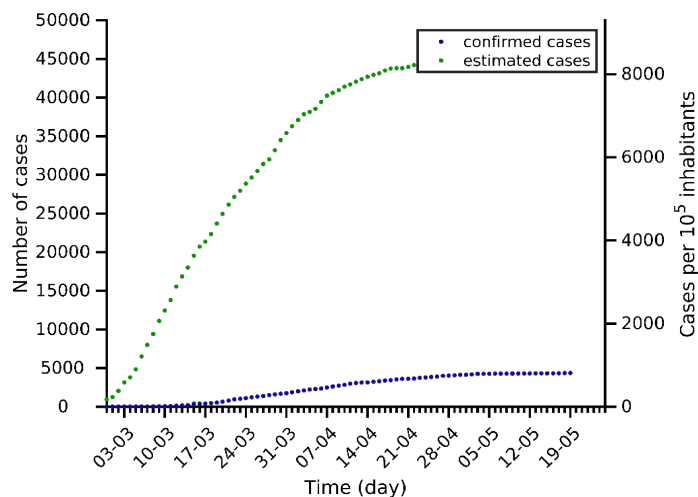
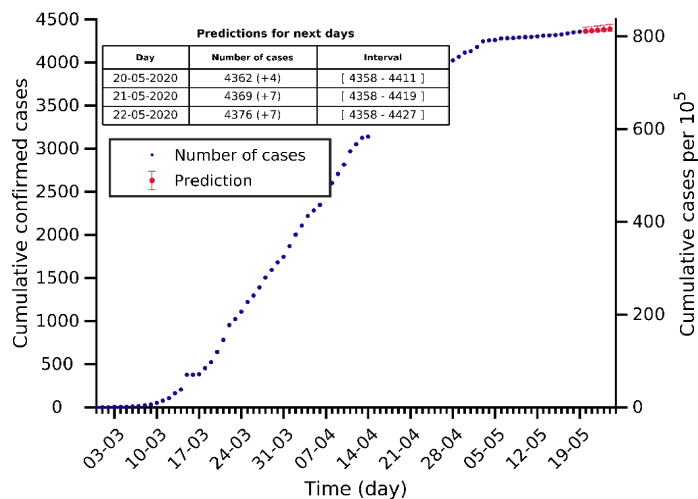
Campania 19-05-2020. Population: 5.8M. Current cumulated incidence: 81/10⁵



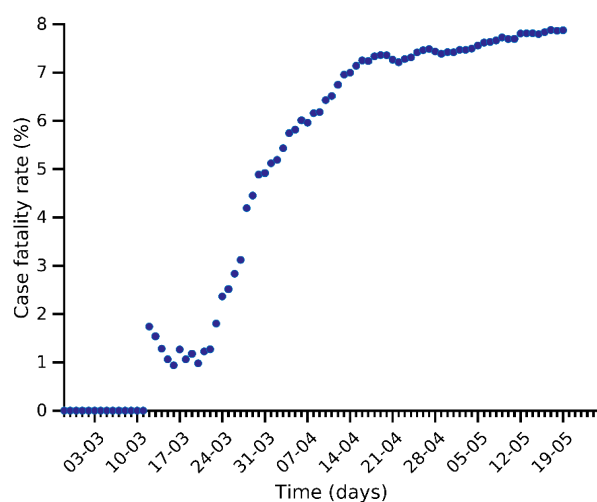
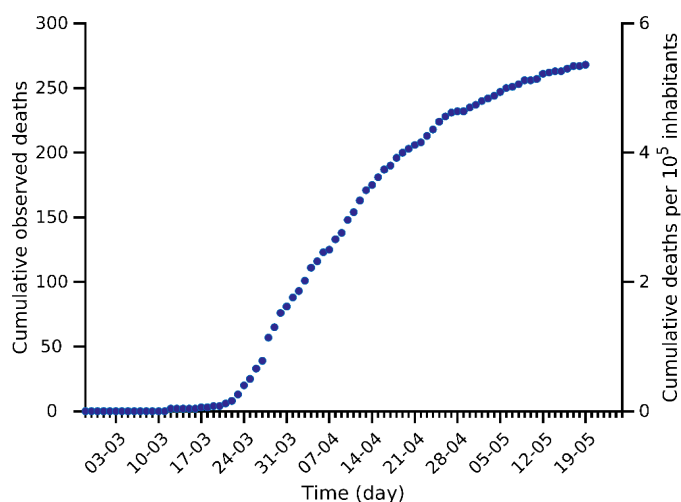
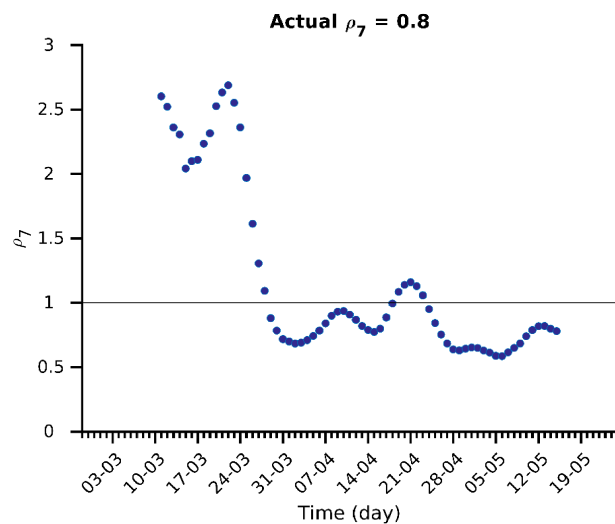
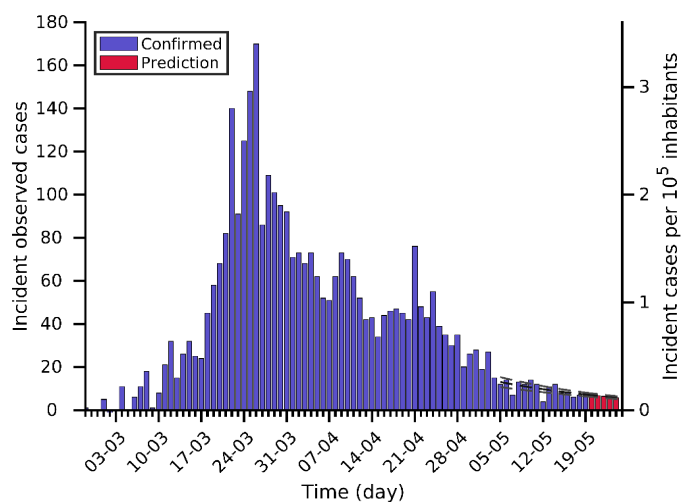
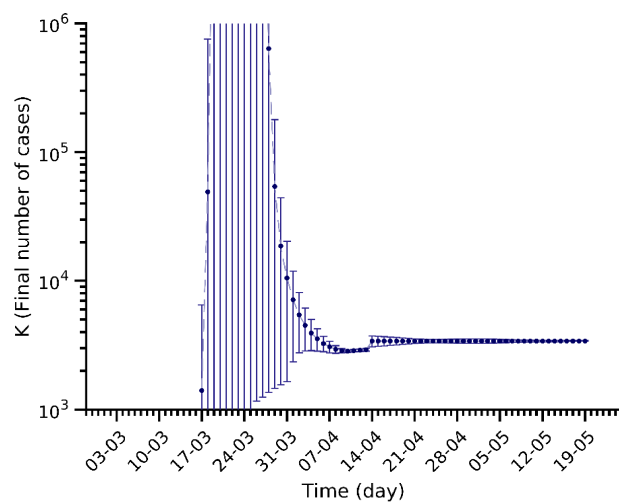
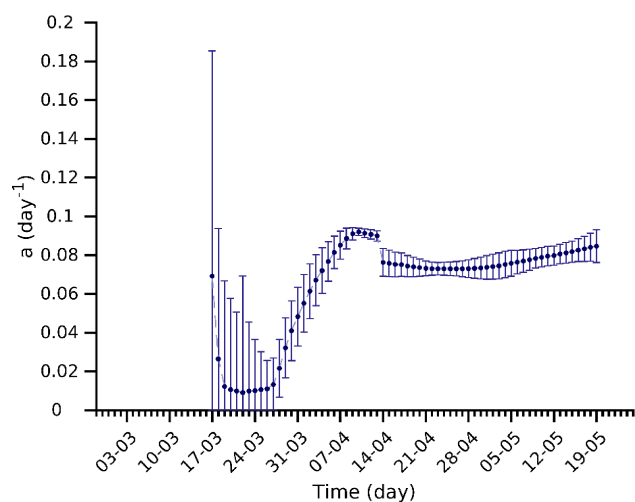
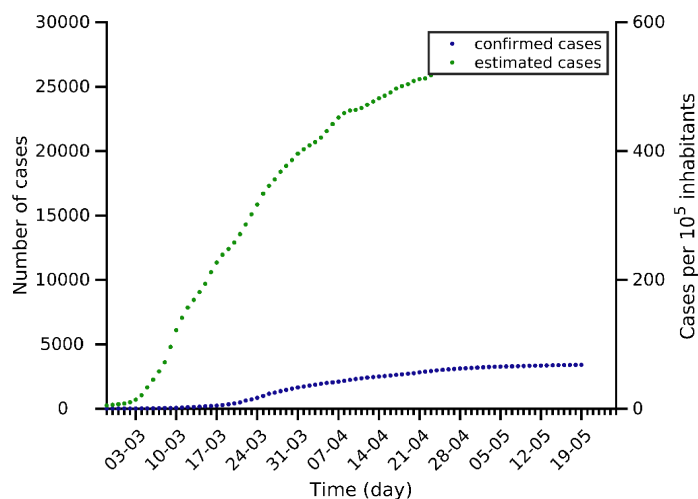
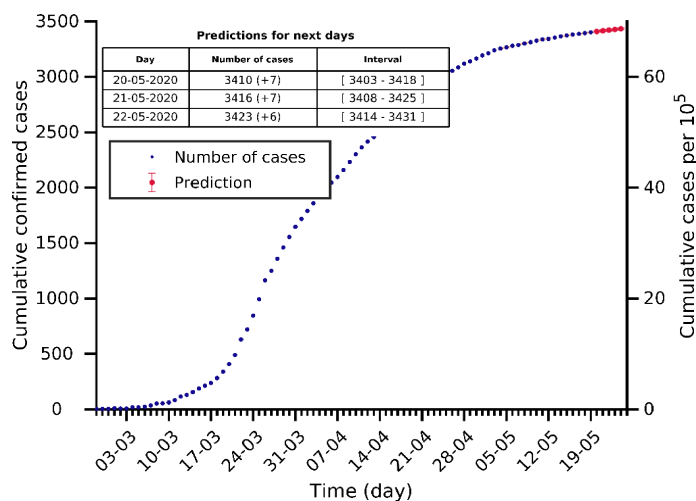
Puglia 19-05-2020. Population: 4.0M. Current cumulated incidence: 109/10⁵



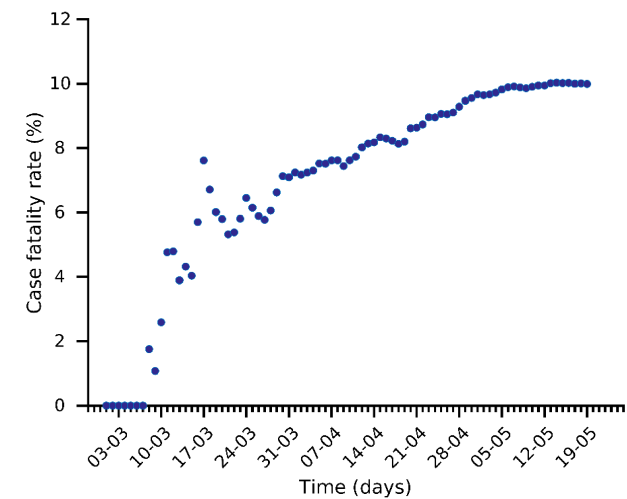
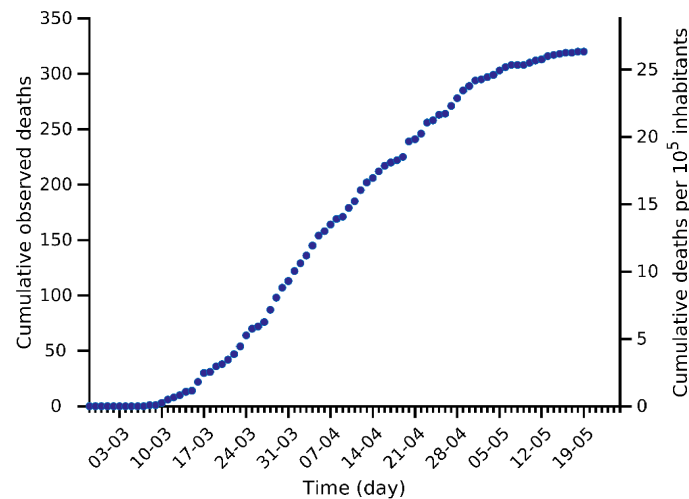
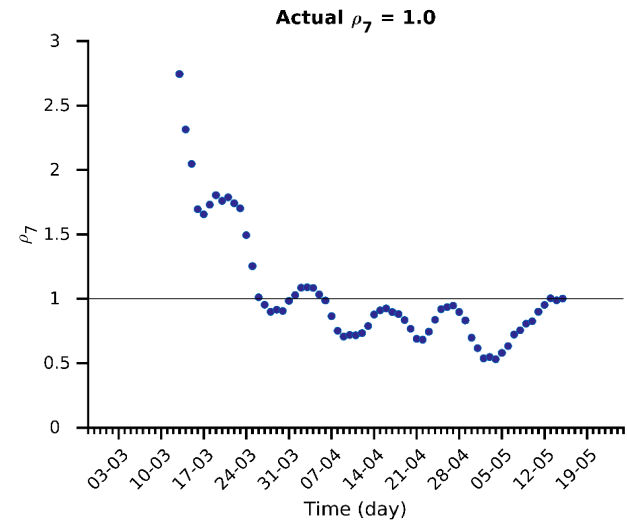
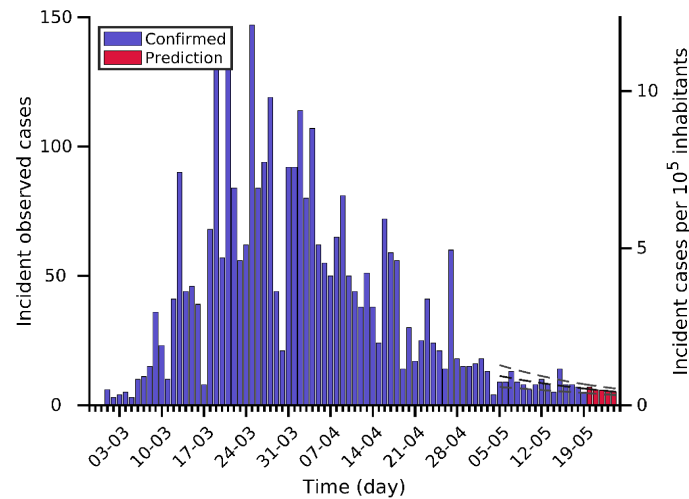
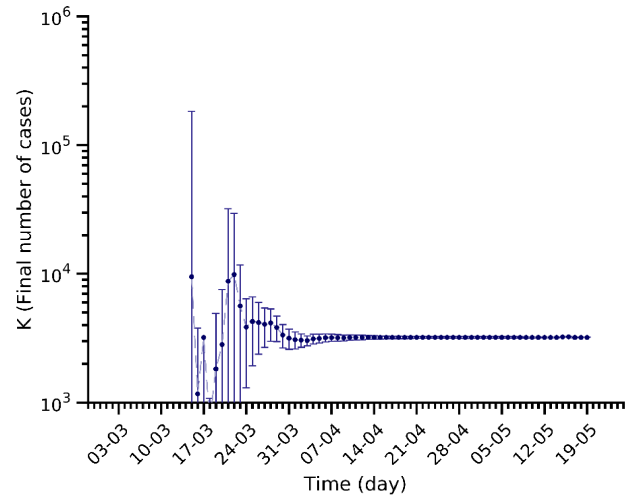
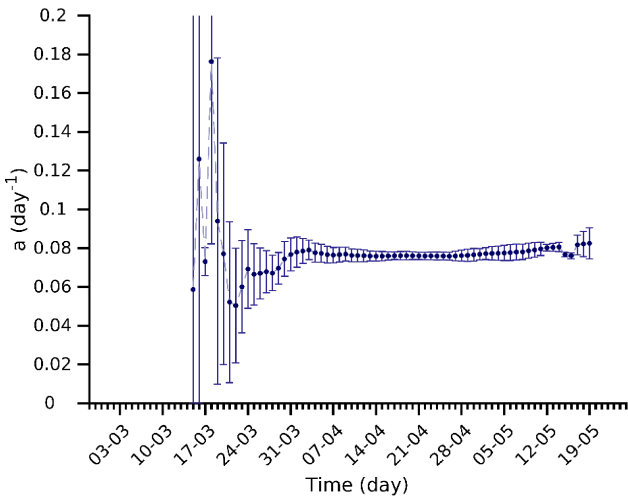
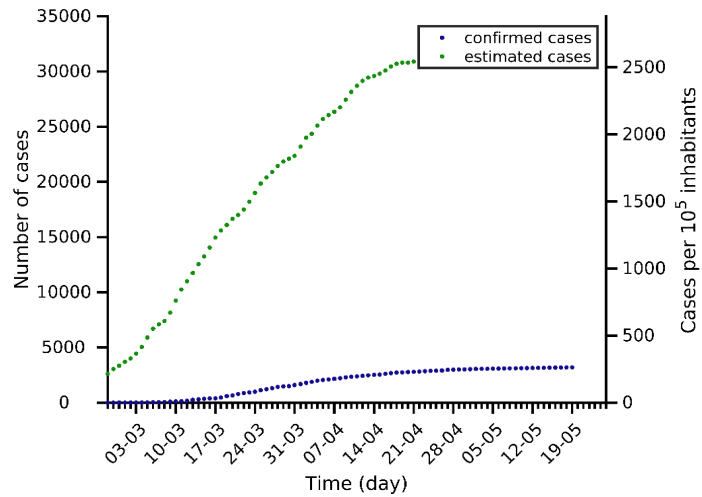
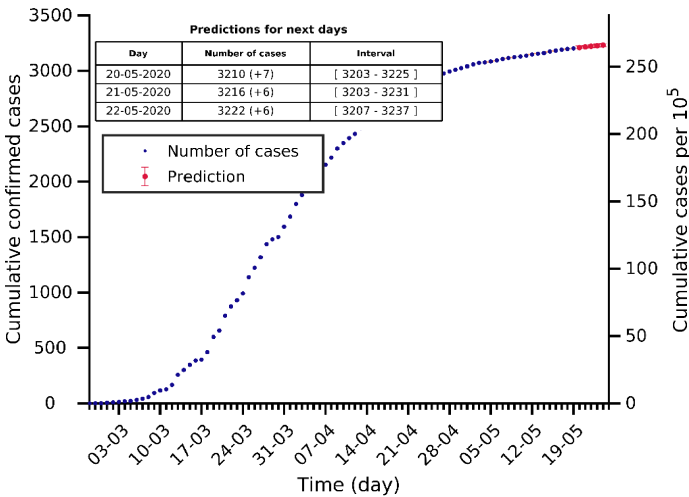
Trento 19-05-2020. Population: 0.5M. Current cumulated incidence: 810/10⁵



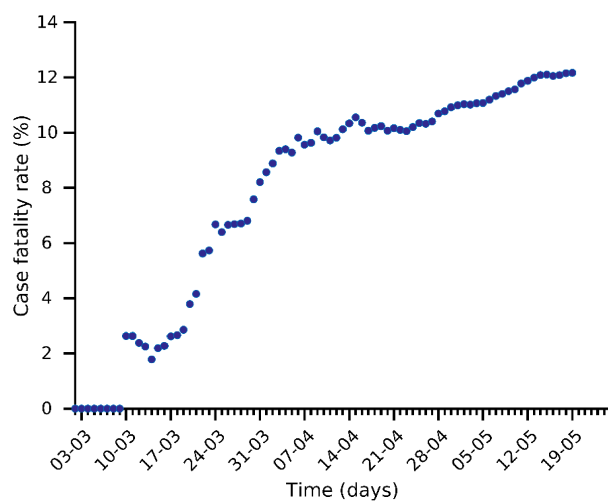
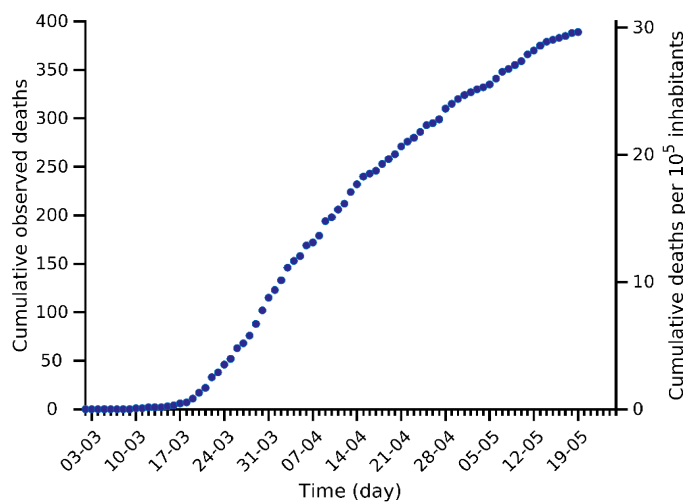
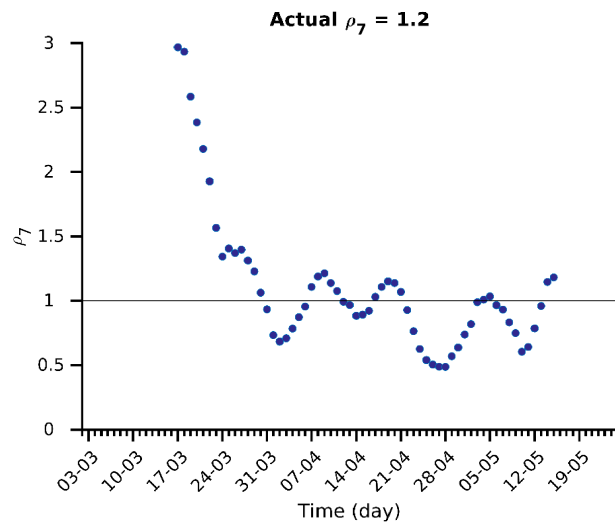
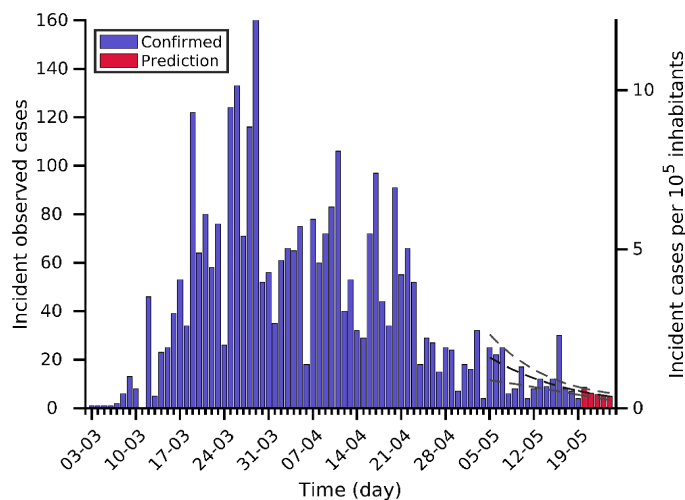
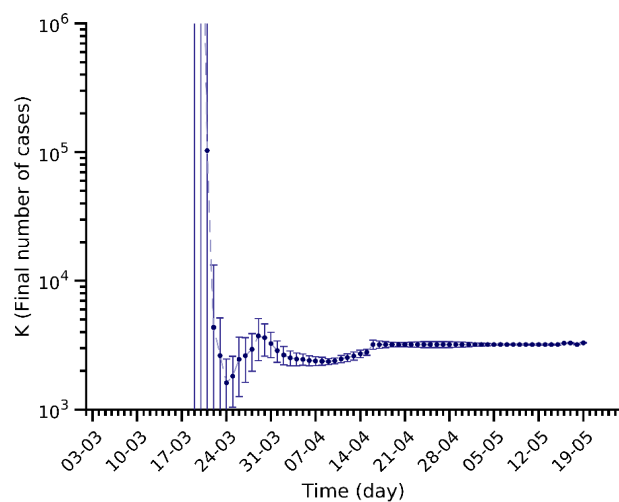
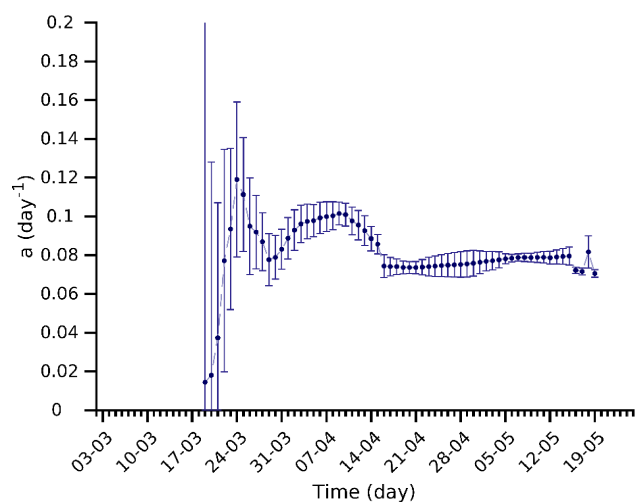
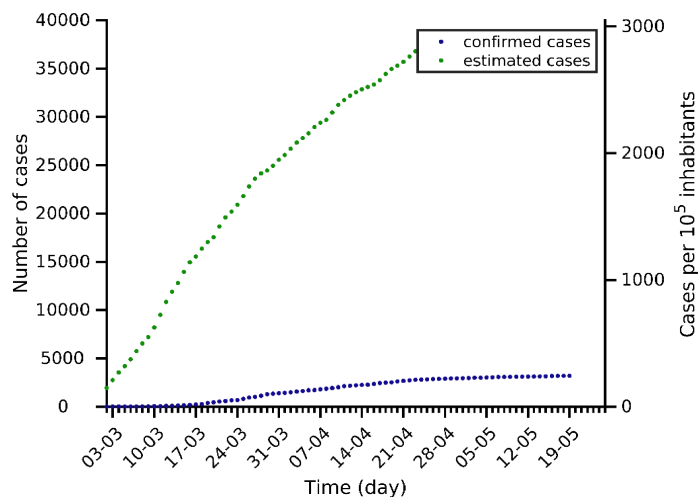
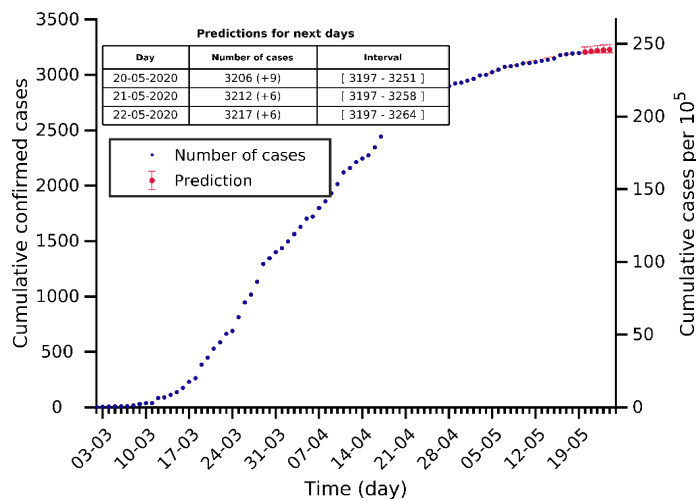
Sicilia 19-05-2020. Population: 5.0M. Current cumulated incidence: 68/10⁵



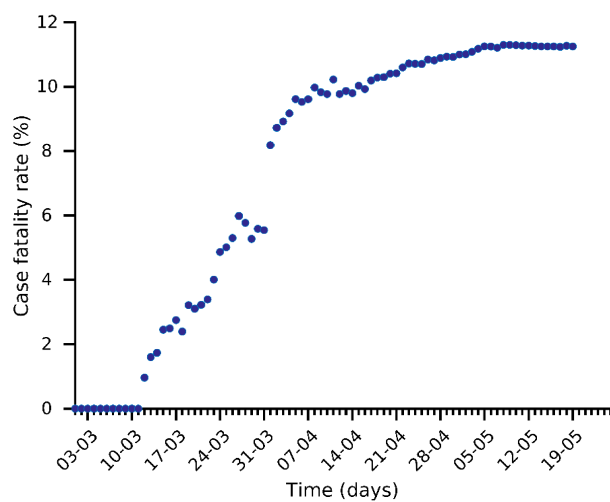
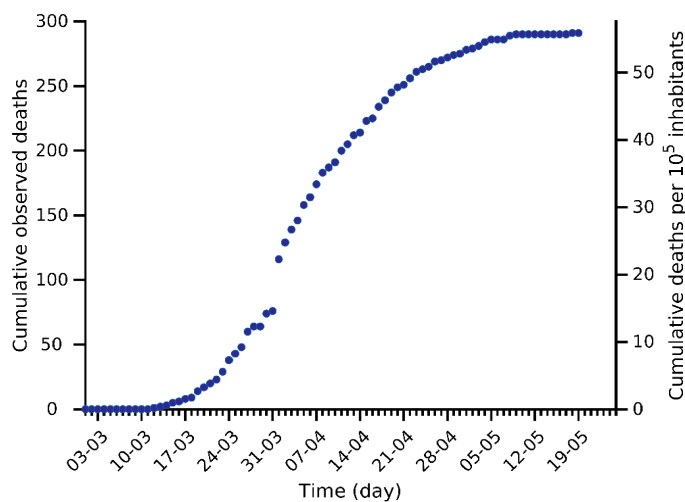
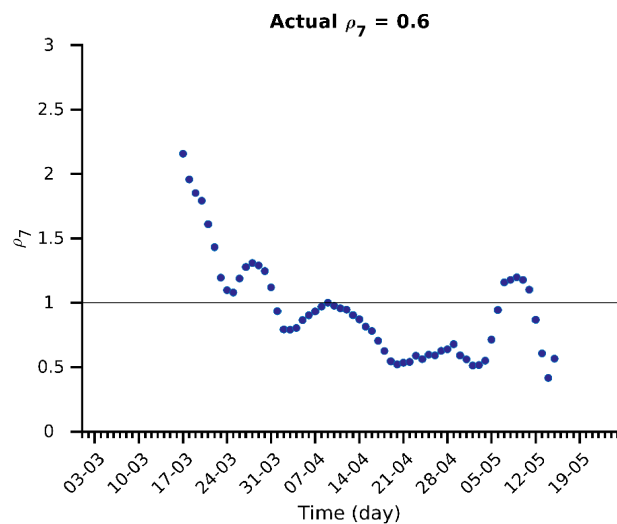
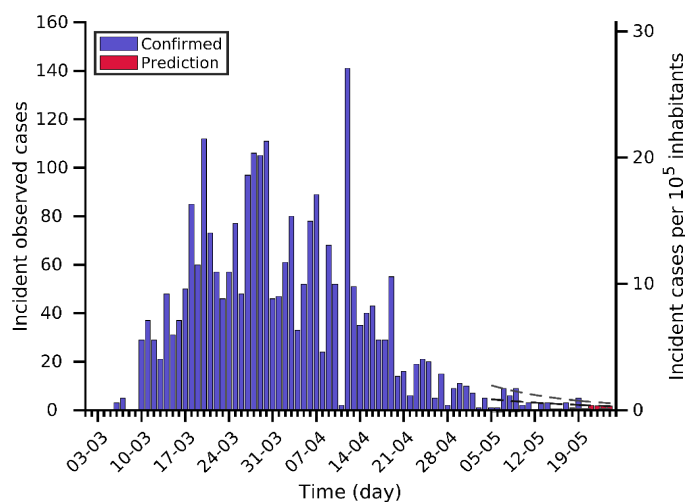
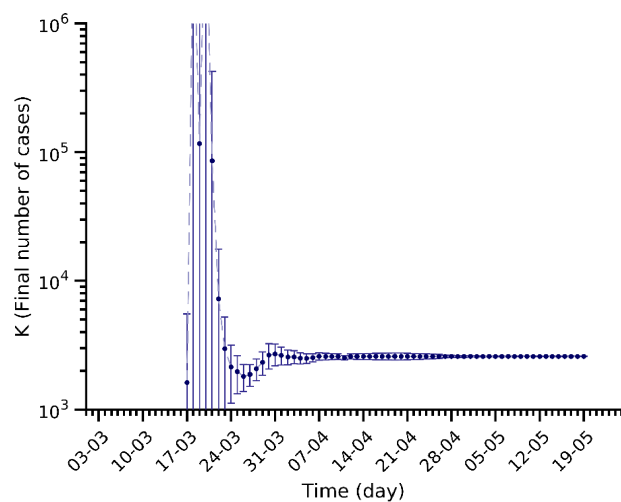
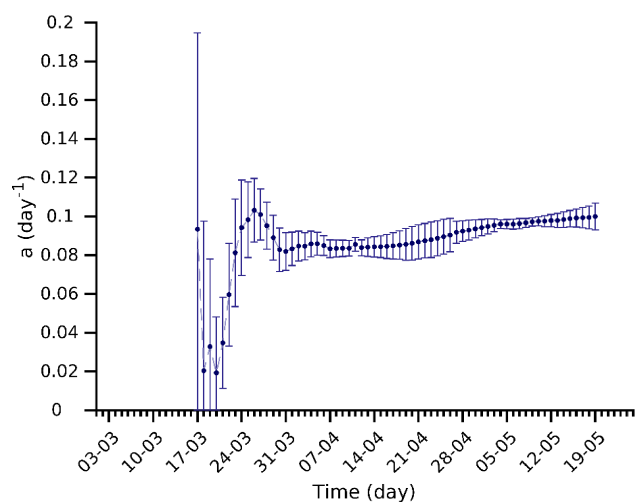
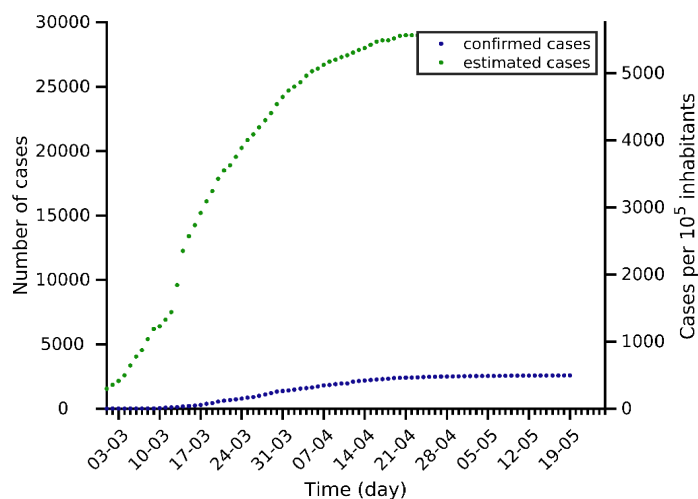
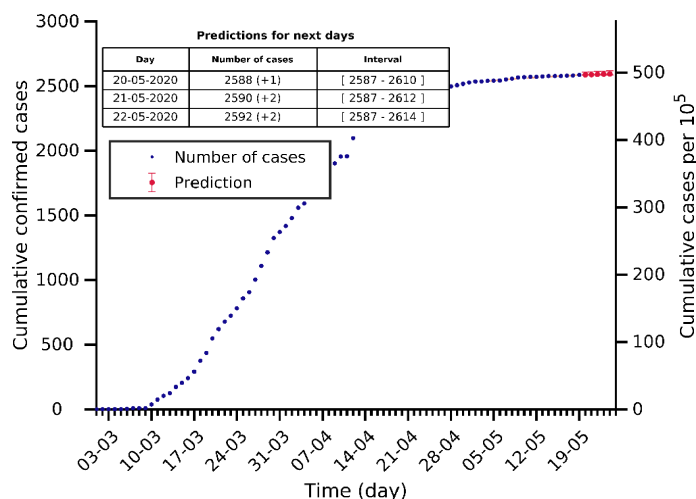
Friuli Venezia Giulia 19-05-2020. Population: 1.2M. Current cumulated incidence: 2



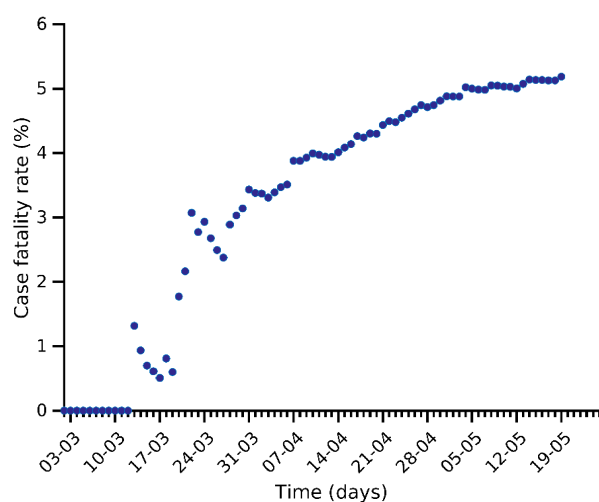
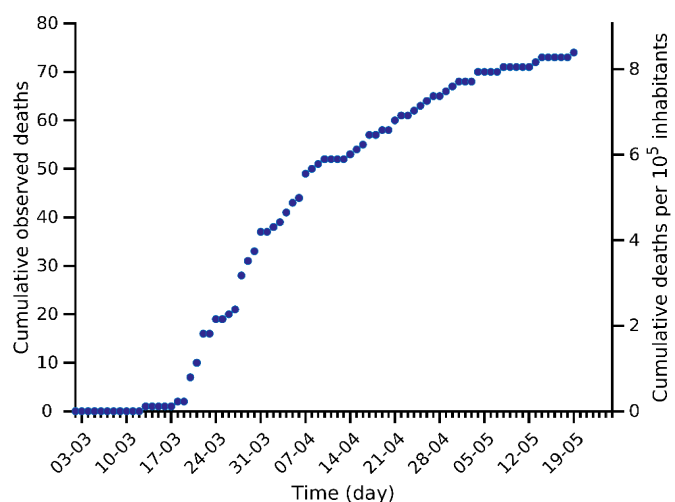
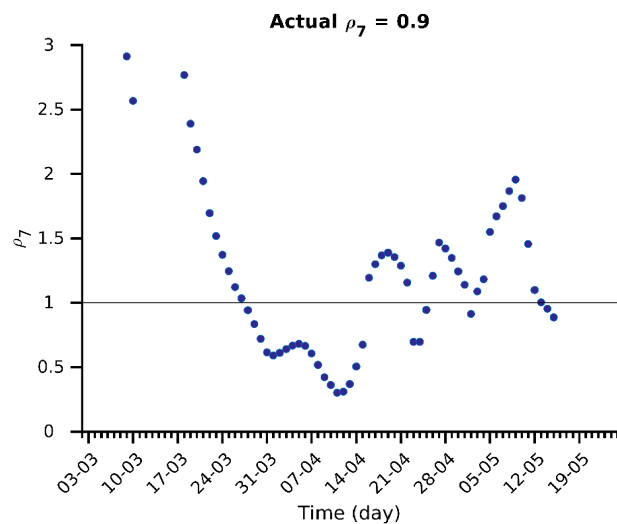
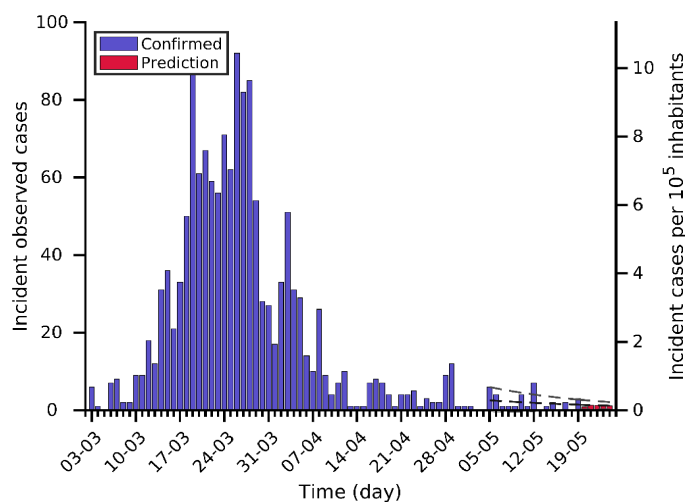
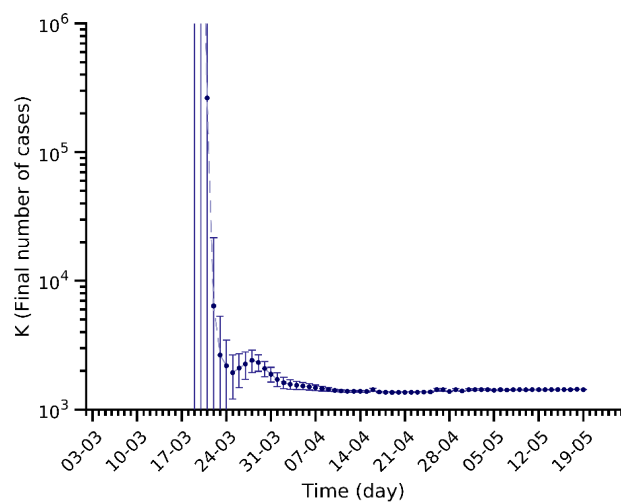
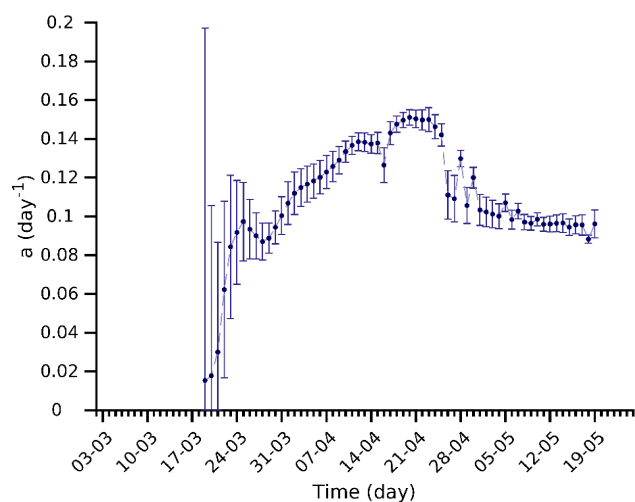
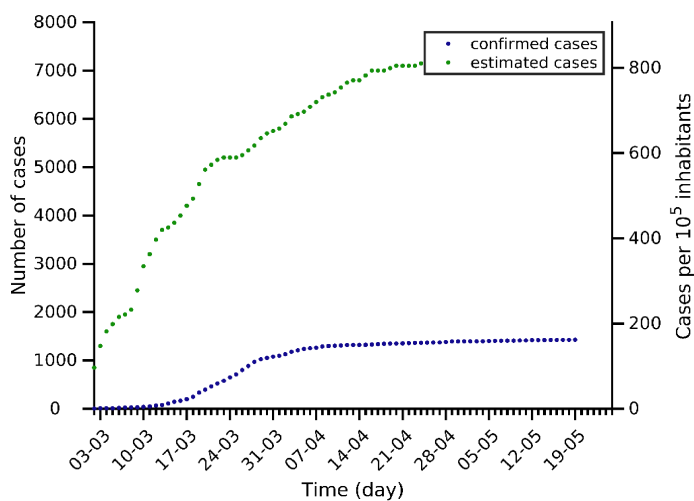
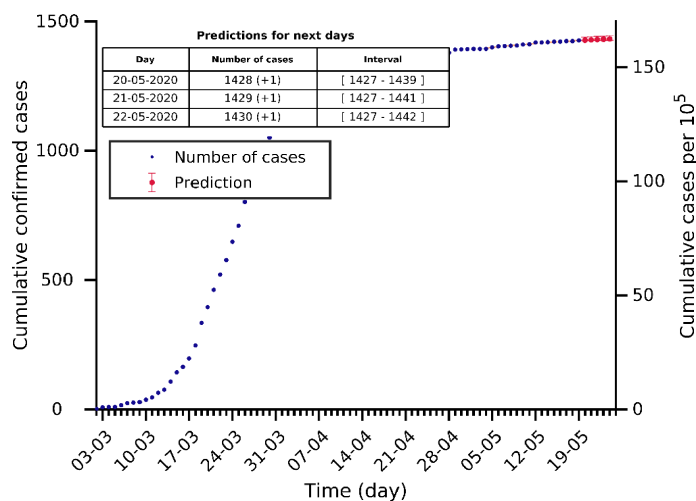
Abruzzo 19-05-2020. Population: 1.3M. Current cumulated incidence: 244/10⁵



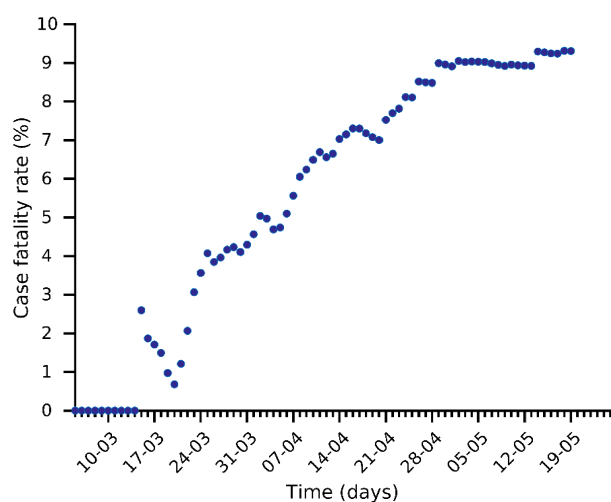
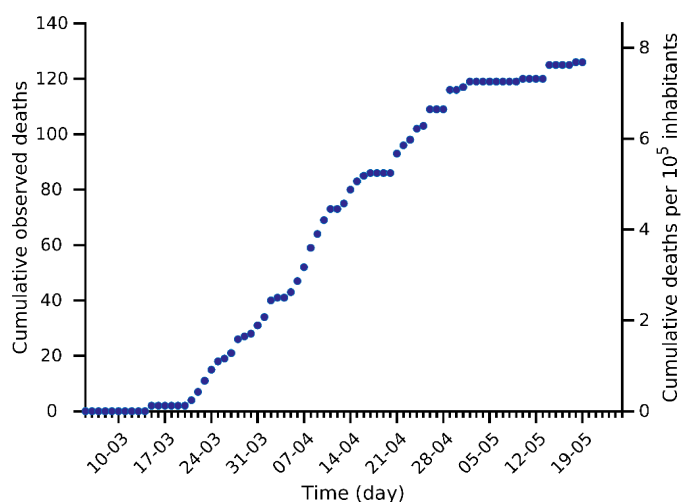
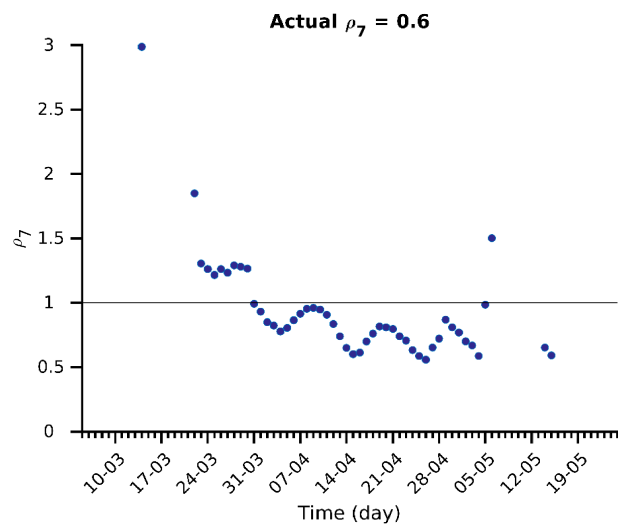
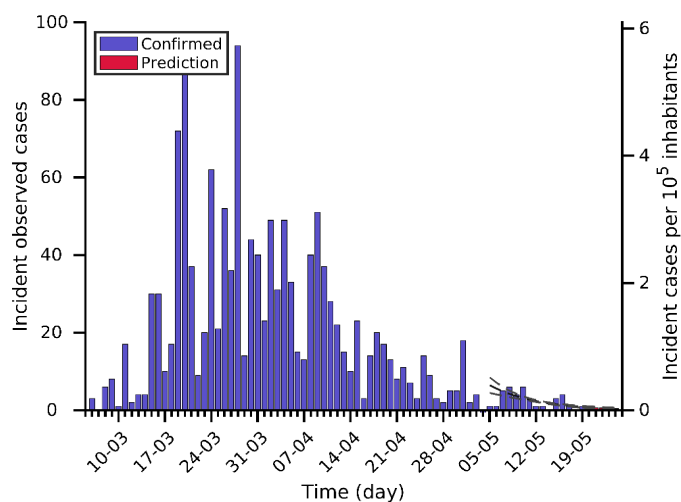
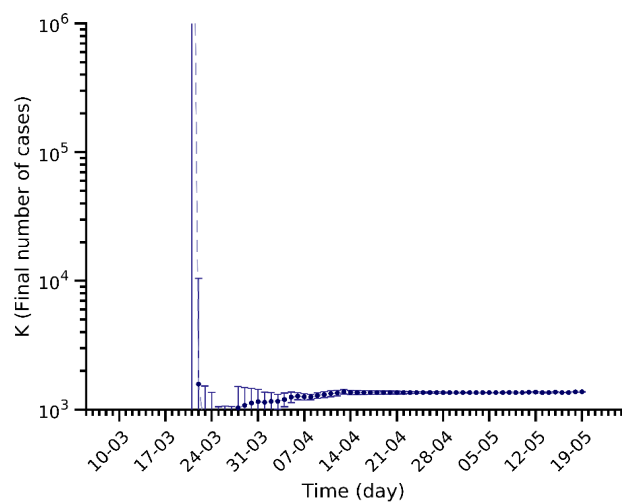
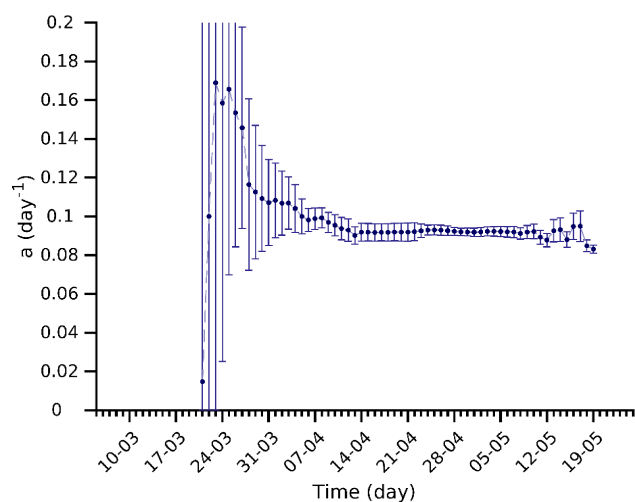
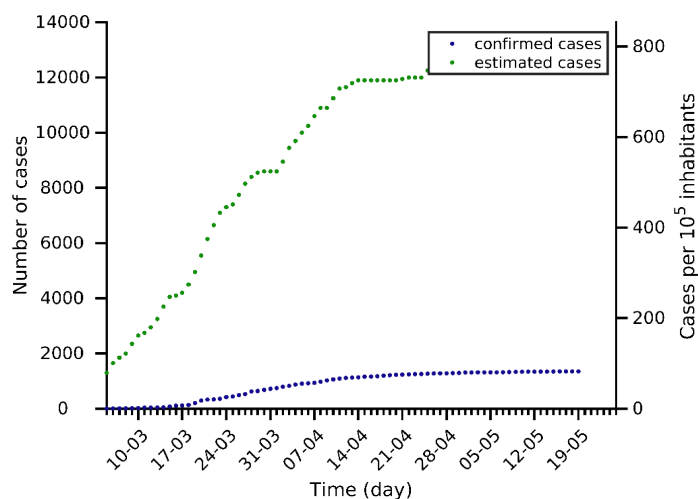
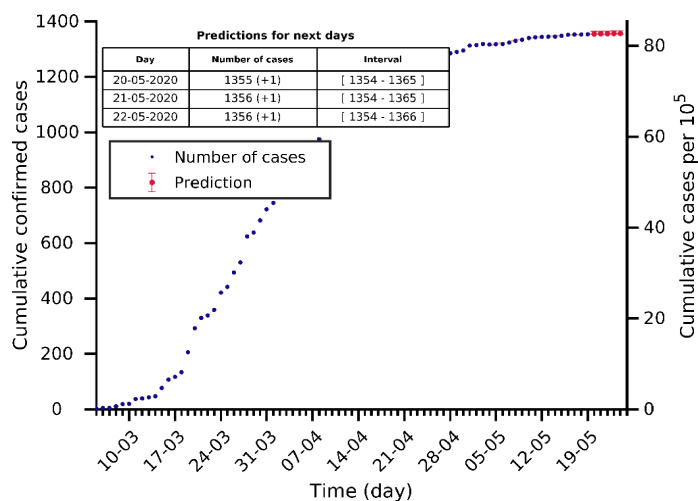
Bolzano 19-05-2020. Population: 0.5M. Current cumulated incidence: 497/10⁵



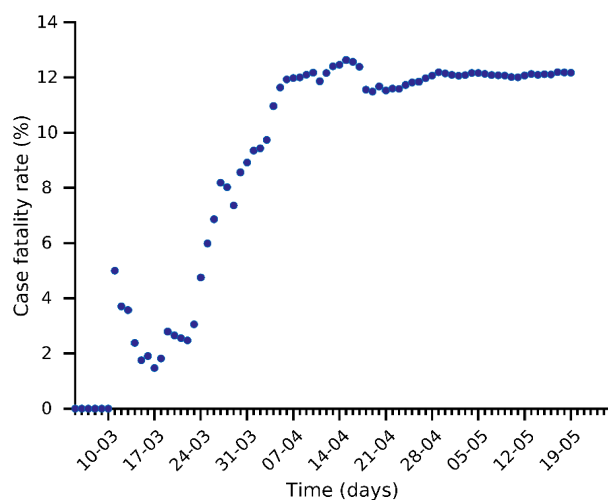
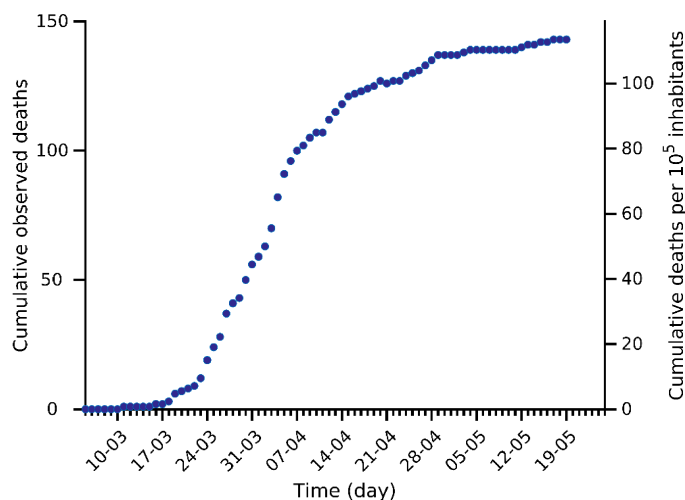
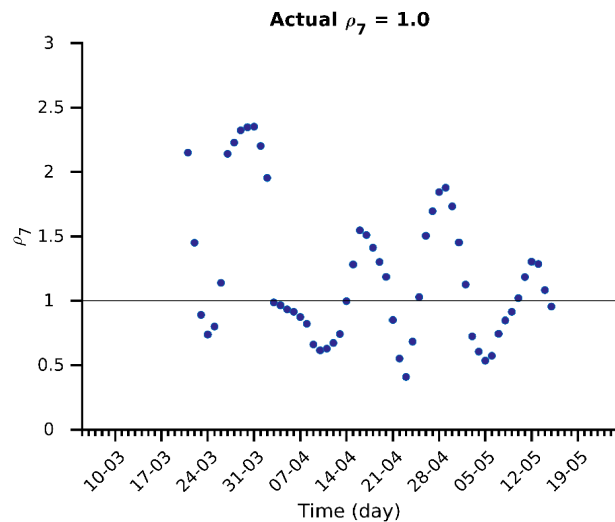
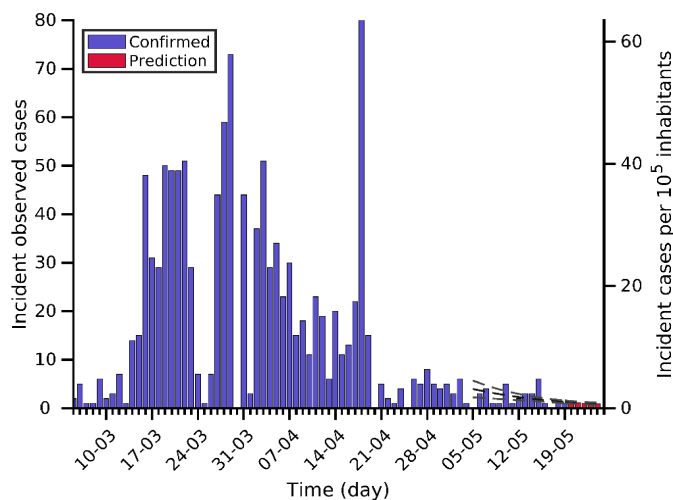
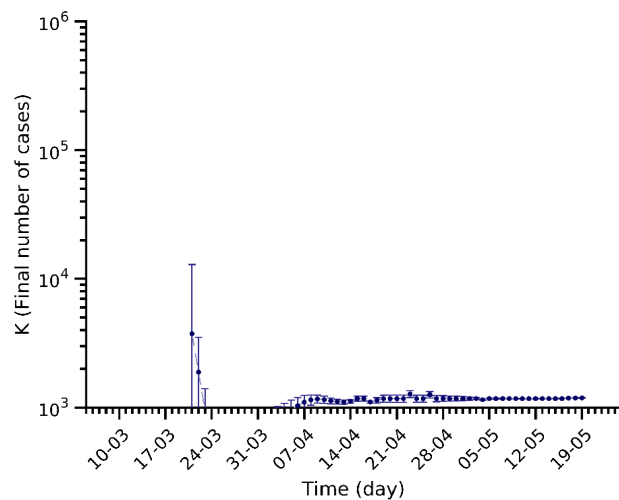
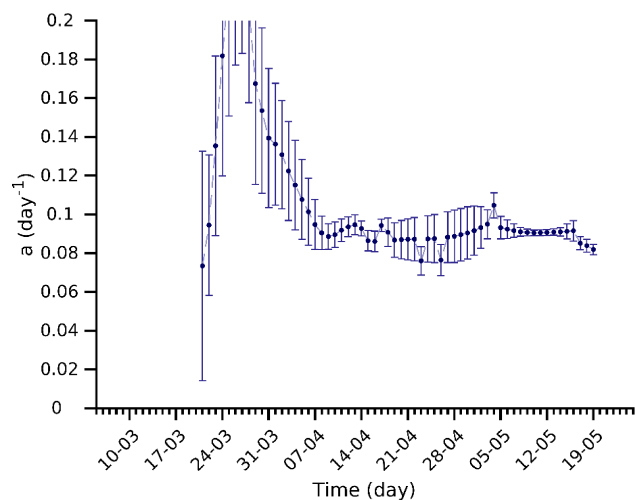
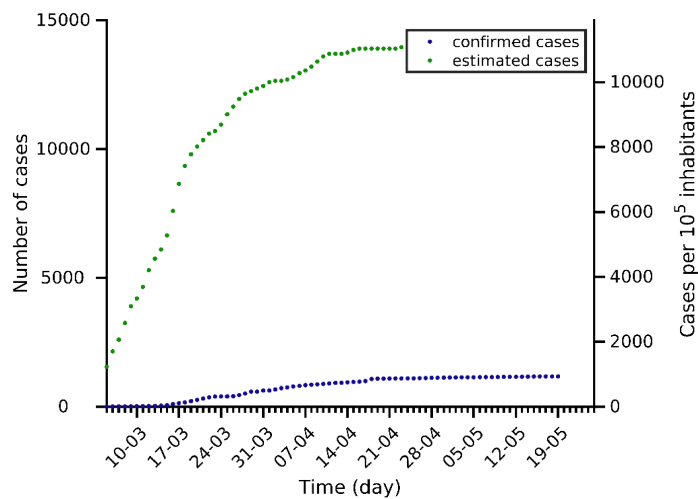
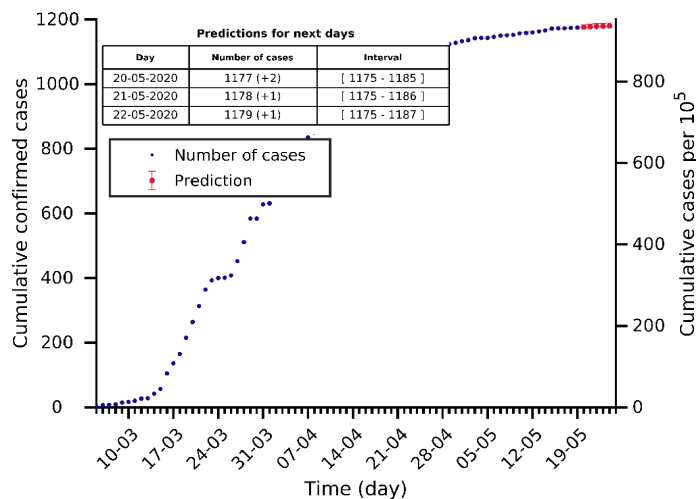
Umbria 19-05-2020. Population: 0.9M. Current cumulated incidence: 162/10⁵



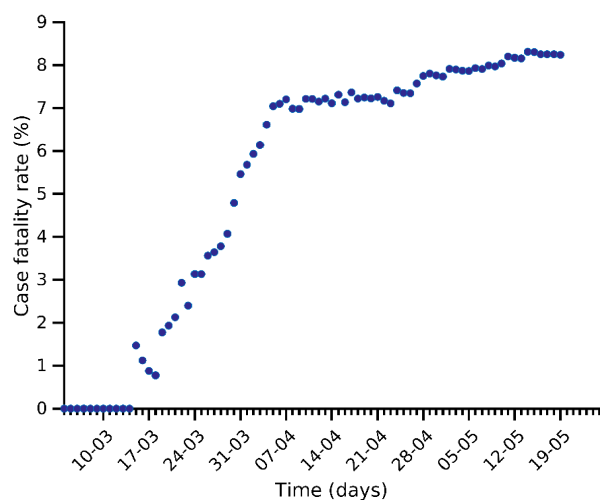
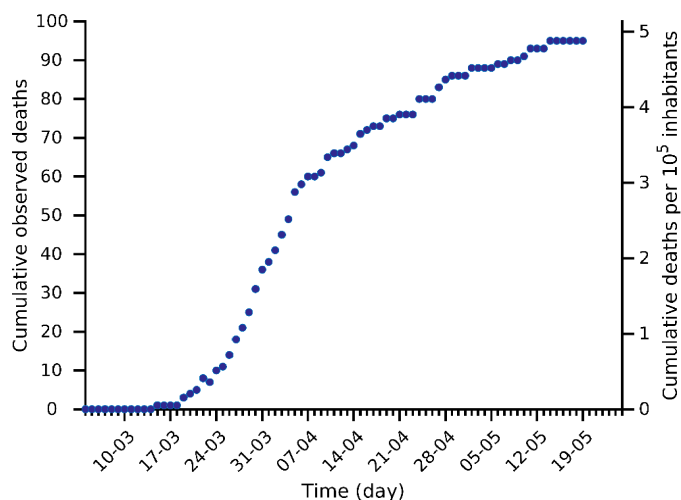
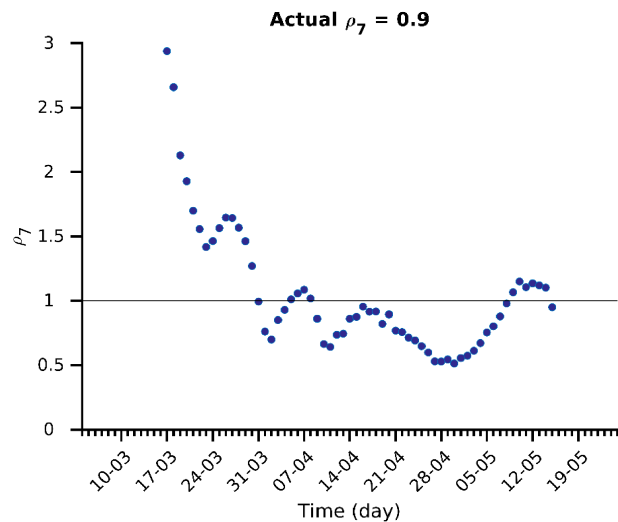
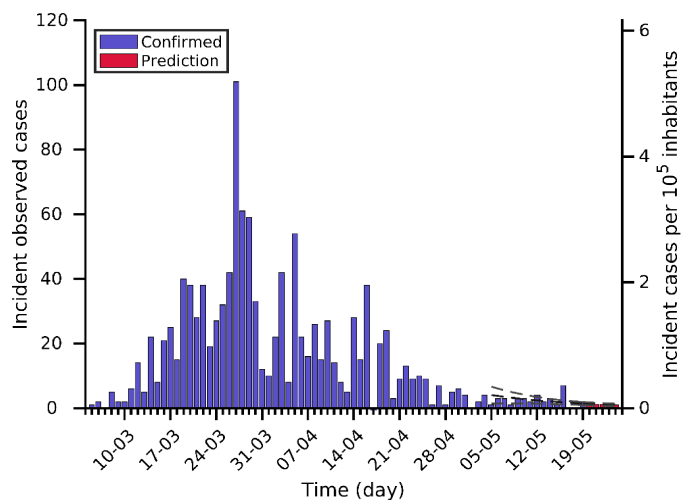
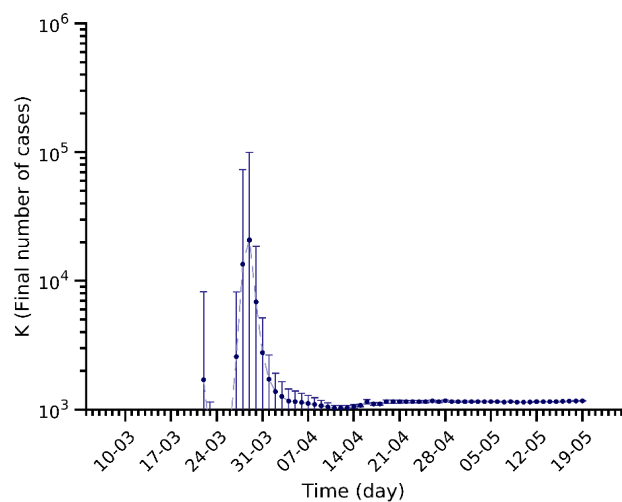
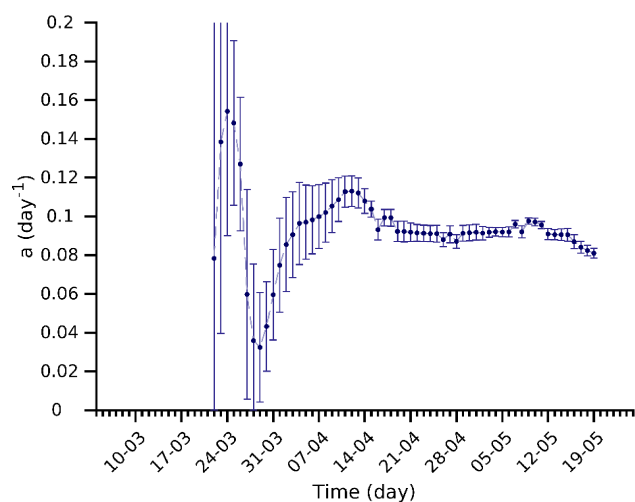
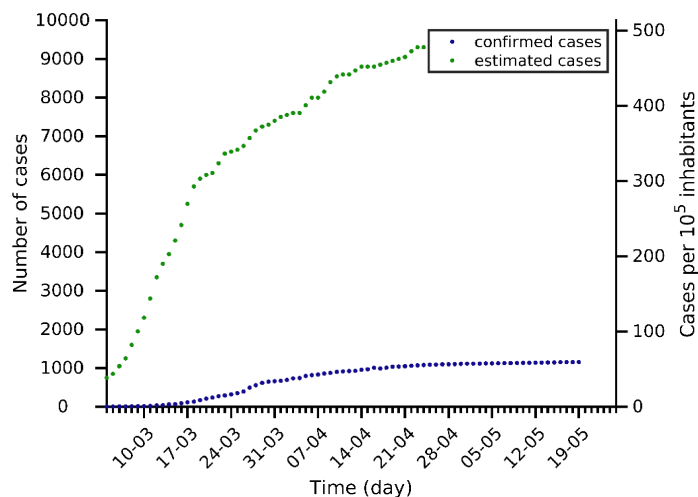
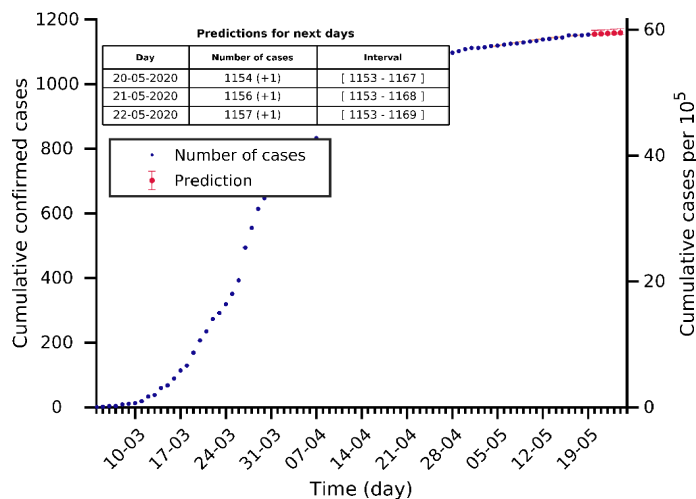
Sardegna 19-05-2020. Population: 1.6M. Current cumulated incidence: 83/10⁵



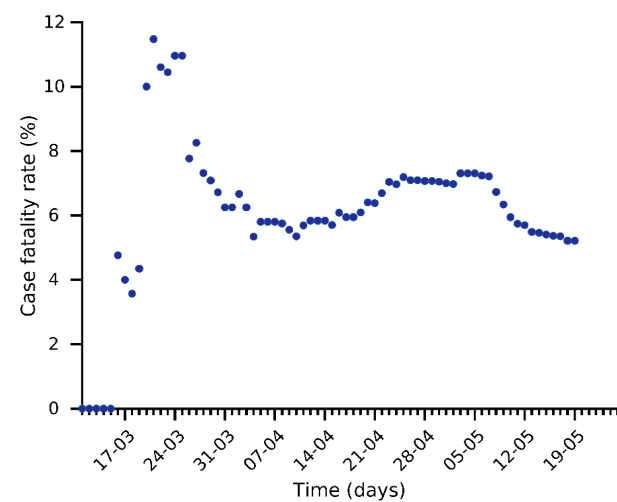
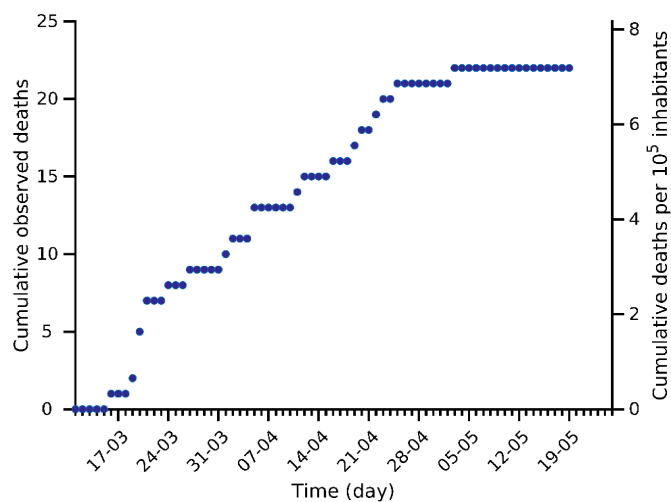
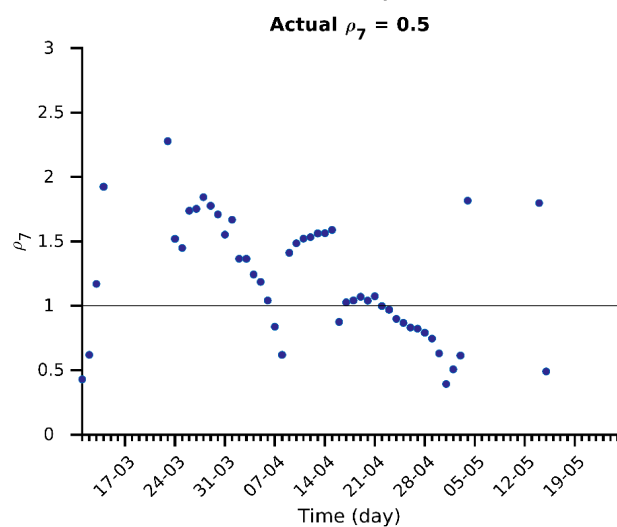
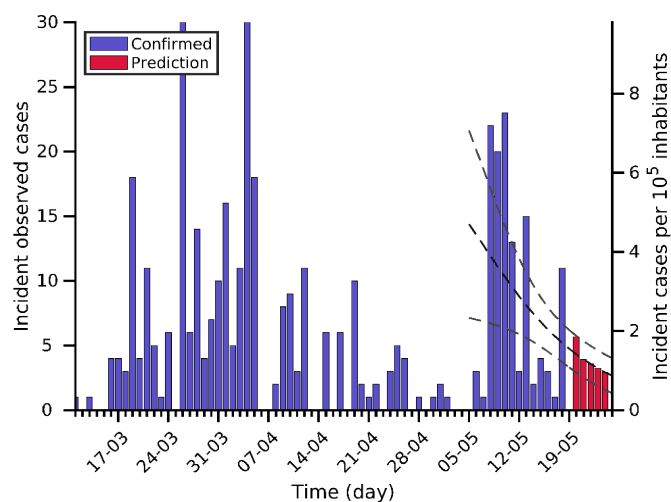
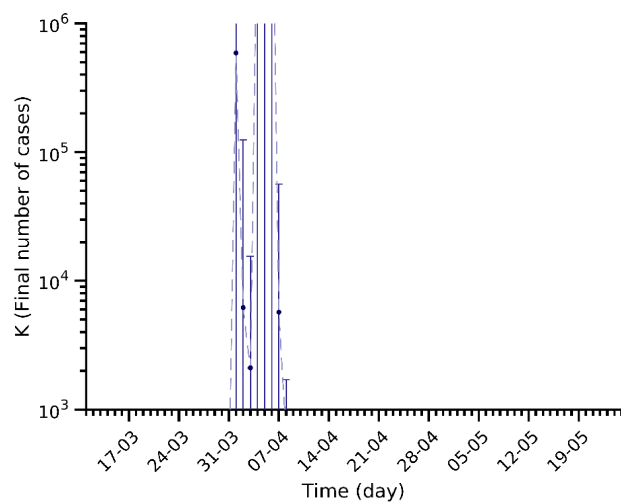
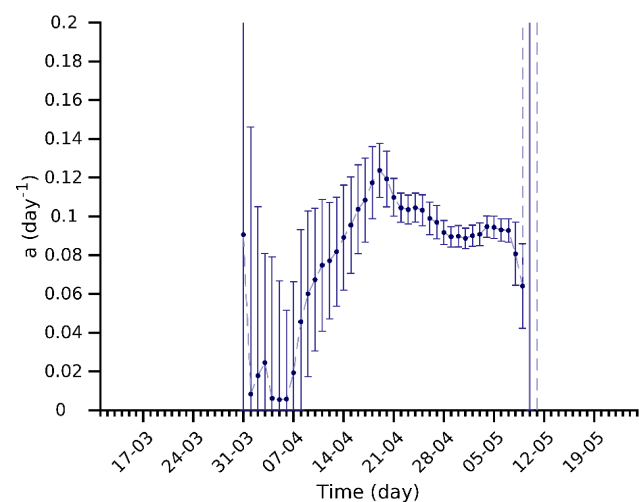
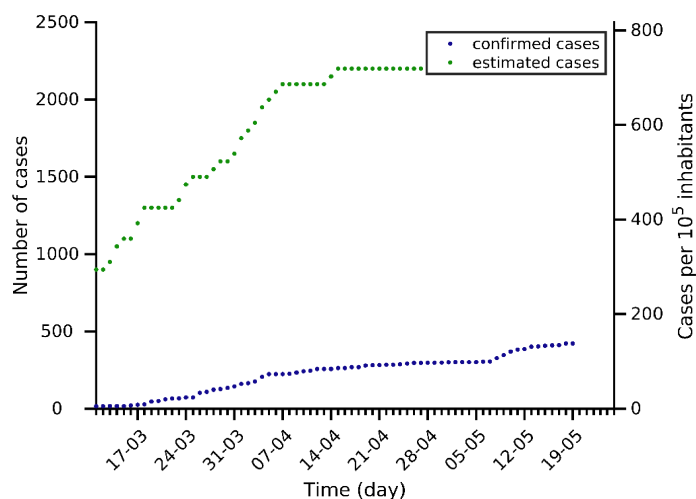
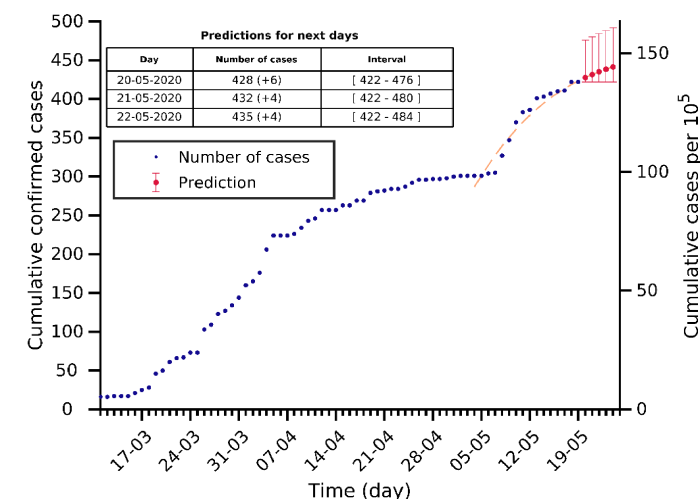
Valle d'Aosta 19-05-2020. Population: 0.1M. Current cumulated incidence: 933/10⁵



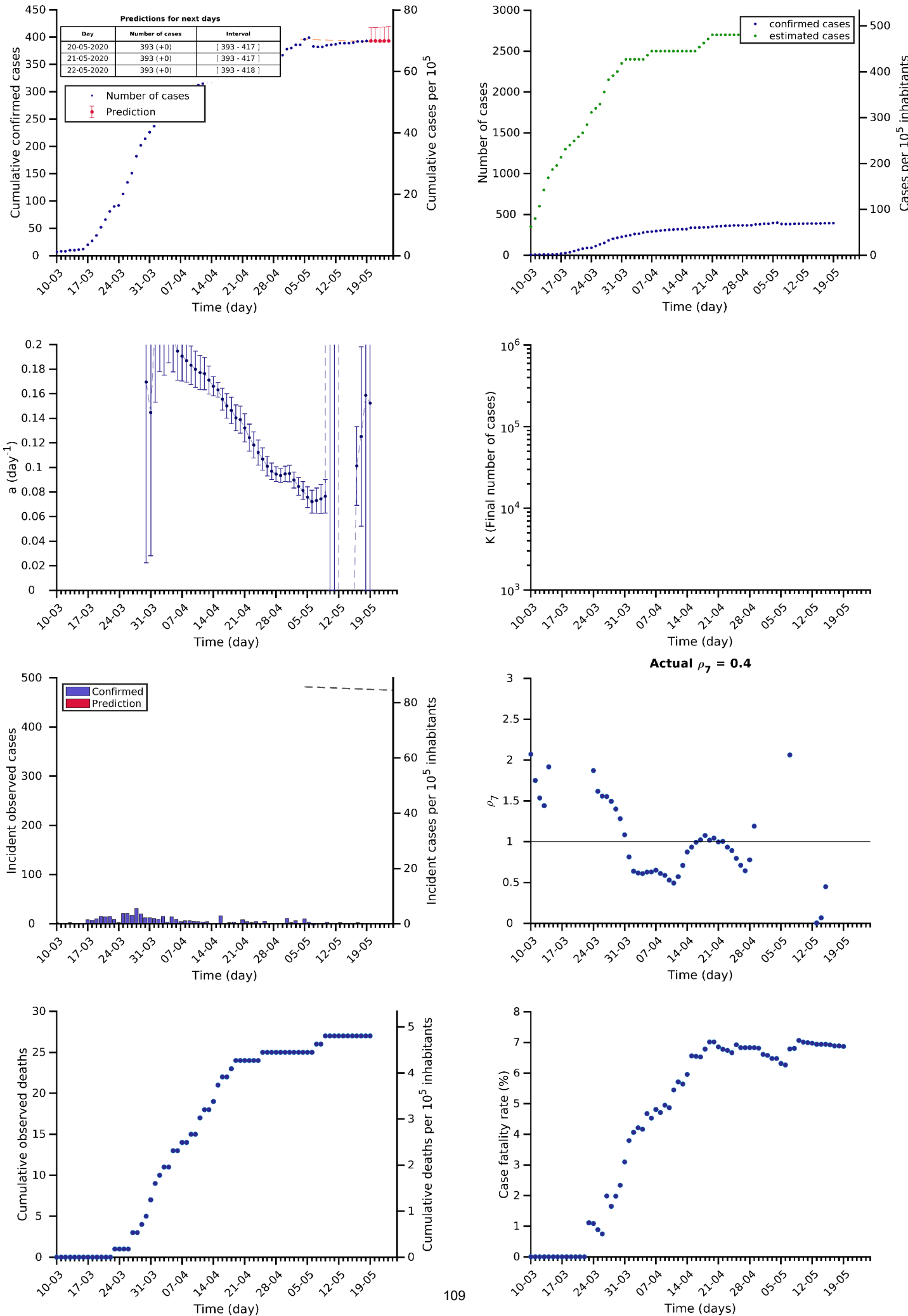
Calabria 19-05-2020. Population: 1.9M. Current cumulated incidence: 59/10⁵



Molise 19-05-2020. Population: 0.3M. Current cumulated incidence: 138/10⁵



Basilicata 19-05-2020. Population: 0.6M. Current cumulated incidence: 70/10⁵



Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and <https://covid19.isciii.es/>

Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3